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Plastics

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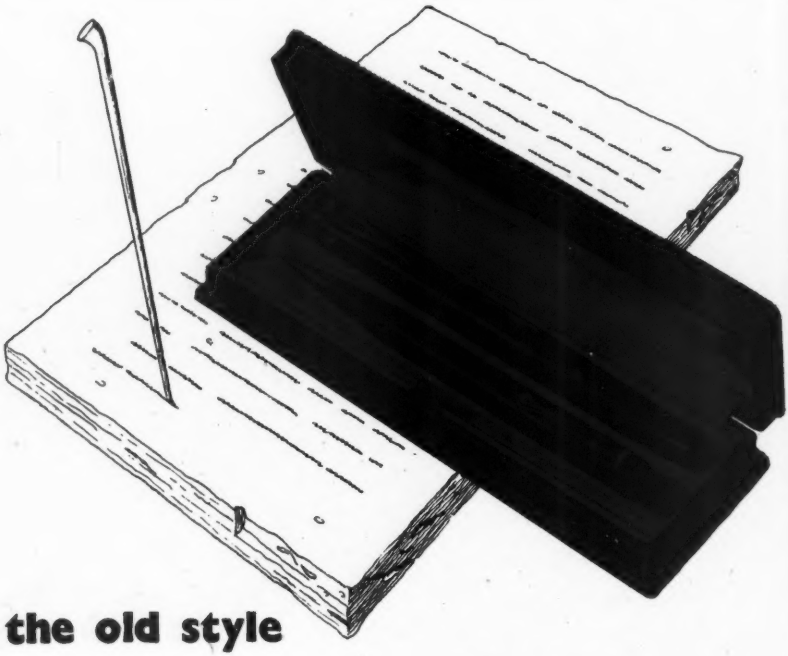

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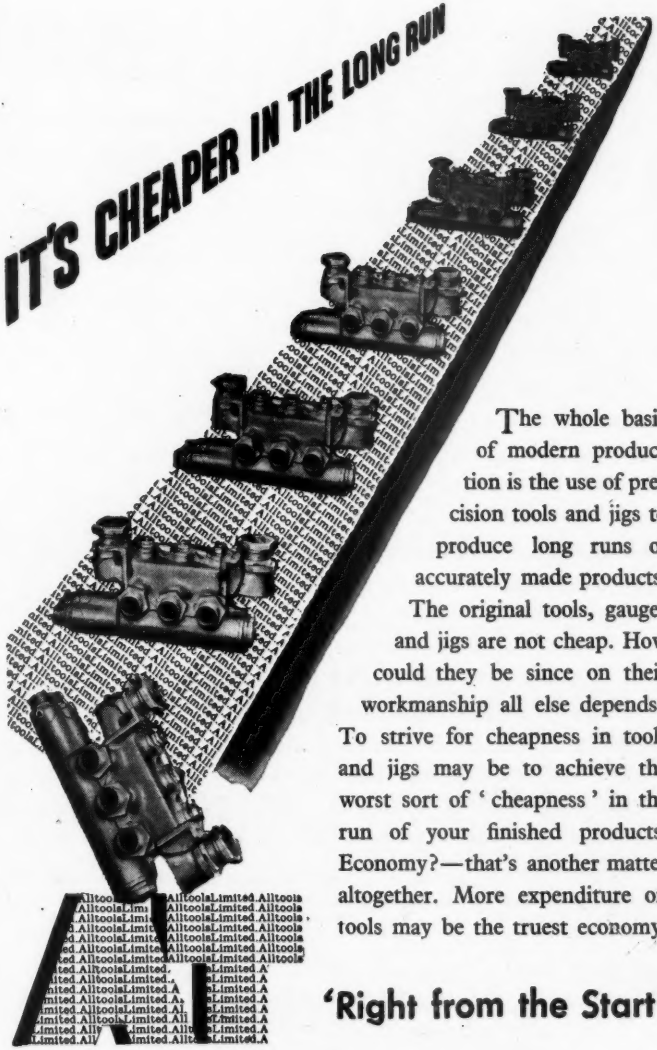

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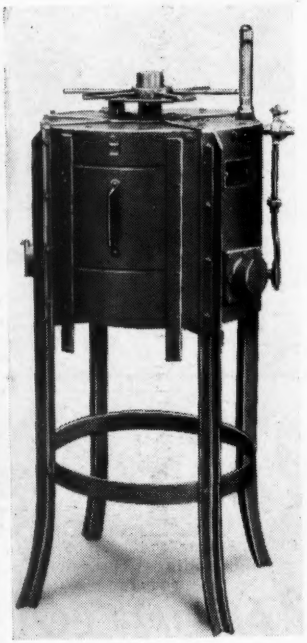

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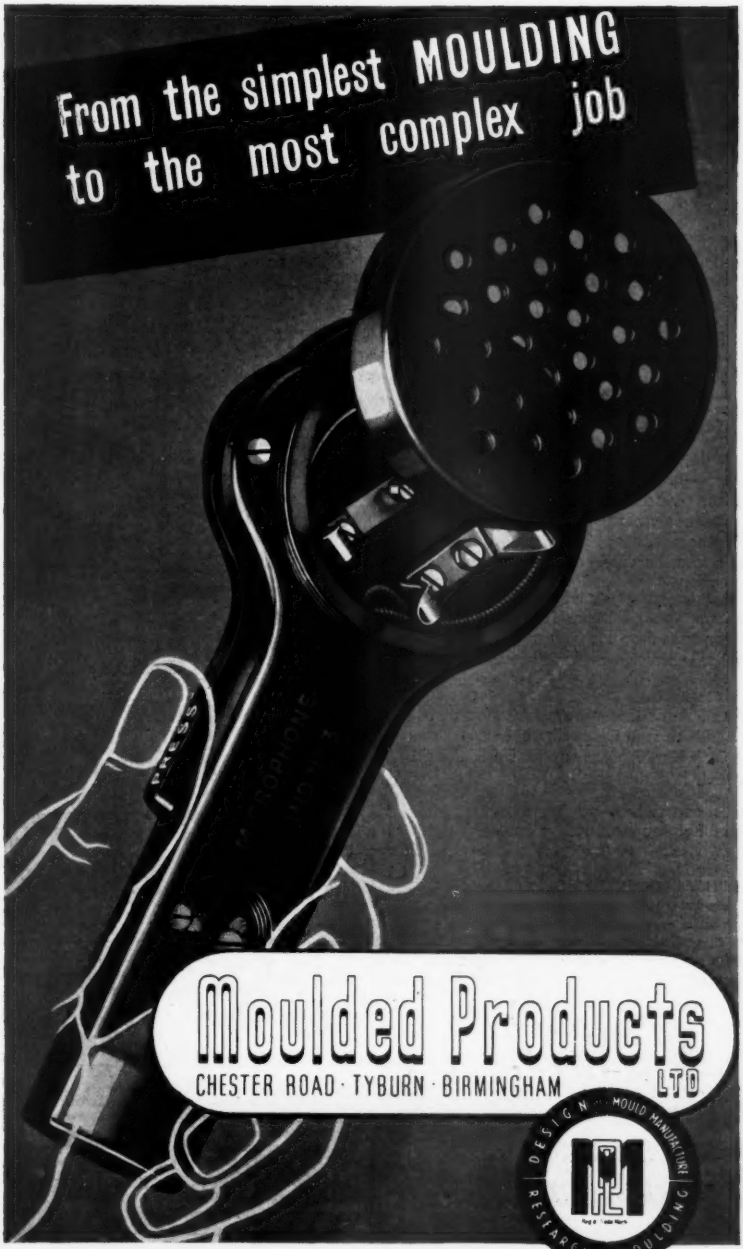
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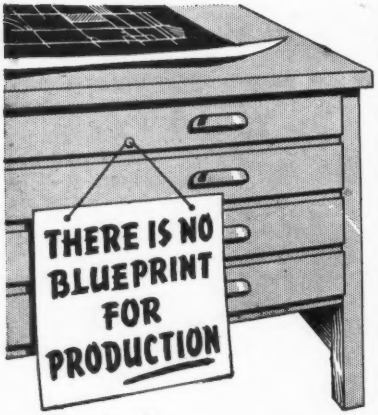

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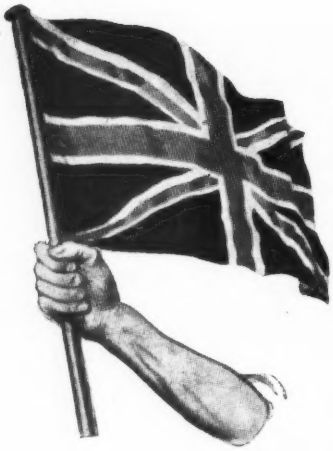

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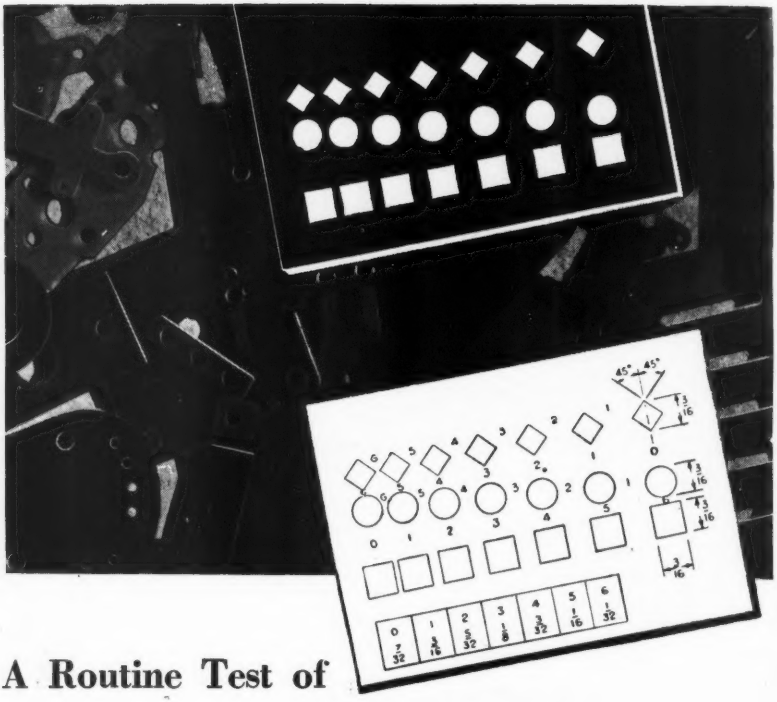

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Vol. IX. No. 100 SEPTEMBER, 1945

Plastics

Dealing with the Manufacture, Uses and Potentialities of Plastic Materials

Proprietors - - TEMPLE PRESS LIMITED
Managing Director - ROLAND E. DANGERFIELD

Editor - - M. D. CURWEN, B.Sc., A.R.I.C.
Offices - Bowling Green Lane, London, E.C.1

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NOTICES

"PLASTICS" is published in London, England, on the second Wednesday of the month.

All instructions, matter and passed proofs for all kinds of advertisements must reach the Head Office of "PLASTICS" by the 28th of each month to ensure insertion in the following month's issue.

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EDITORIALS

Baekeland and Bakelite

FEW will challenge the statement that had there never been a Baekeland the plastics industry to-day would have been but a pale, emaciated reflection of its present self. This is true in spite of the contemporary work of others like Swinburne and Redman, whose valuable researches became dimmed in the light of the more brilliant industrial endeavours which resulted in Bakelite.

It is true, in spite of the fact, moulding resins made from phenol and formaldehyde in the same way as they are to-day would eventually have appeared, for such is the way of chemical science.

Phenolic resins, now made all over the world, form the main pillar of the industry, as it is at present, and they hold a unique position among the whole range of plastics. Nearly 40 years ago they were the answer to the electrical industry's prayer. Because of their strength, rigidity and heat resistance, no other plastic has yet replaced them from the hold they have in pressure moulding. Economically, if we omit the rubbers and rubber-like plastics and the plastic fibres, they are still the most important.

The lustre of Baekeland, the great industrial scientist, will shine for ever in chemical history, and it is a good thing to reflect on his life and on his work.

At the Royal Institute in London, Mr. H. V. Potter, B.Sc., F.I.C., M.I.Chem.E., the present managing director of Bakelite, Ltd., who had considerable contact with Baekeland when he lived, has recently told the story.

It has been related sketchily before, but Mr. Potter, in his Baekeland Memorial Lecture, fills in the bare bones we know with the warm flesh of humanity, and Leo Hendrik Baekeland, the Belgian, who was born in 1863, becomes not only a great industrial chemist, but also a great man.

We shall not do more here than abstract one point of the story for our future guidance.

After he had become assistant professor of Chemistry in the University of Bruges at the age of 26, he won a travelling scholarship. Apparently the first country he visited was England. Potter relates that "he approached Williamson, of University College, London, but after looking over the chemistry department and discussing his future work with Williamson, he was not impressed with the conditions he found, so he visited Oxford with the hope that he might find facilities for studying and then carrying on practical work in applied chemistry, but he discovered that no gentleman there worked with his hands as well as his head —so he departed forthwith.

"He then went to Edinburgh and there came in contact with Crum Brown, who had a fine laboratory and was surrounded by a band of very able young research workers, including Walker, Alexander Smith and Masson, among others. He was much impressed with his reception and with the possibilities in University College, Edinburgh, and had decided to work there, but similar to other colleges in this country he found there were no facilities for trying out in a more practical way the results of his research. In fact, he said that such a procedure was looked upon at that time as undignified and was in every way discouraged. He accordingly abandoned his idea of working in Great Britain so he sailed to the United States. He had many regrets on leaving Scotland and always retained a warm spot in his heart for Edinburgh and for the enterprise of its University."

Baekeland went to the United States, eventually found what he wanted, and became an American. We do not repeat this story to fill the Vale of Lost Opportunities with futile tears. We tell it so that one day in our own Institutes of

Industrial Sciences our own bright young men and any from foreign countries will be welcomed and given the tools and facilities Baekeland found lacking.

Mystery Story

THE remarkably moving story from Philo Bones's casebook, reproduced on page 433 of this issue, is the first and last of his that will be published. The delicate senses of our readers could stand no more. They will agree with the author that Bones is a fictitious character. We can vouch for the fact that no such name as Dogsboddy can be found in the files of this office.

But the rubber rings are not fictitious, and are there and almost everywhere for all to see. They are, truth to tell, a disgrace to any manufacturer—one might have doubted they were of British origin. We have asked Mr. J. H. Wredden to do the photomacrographs, which are self-explanatory.

It is, however, not clear at whose door the fault lies. While the usual good rings have appeared in the past at very rare intervals, we do not know whether the poor ones only are now available.

At first sight one is apt to blame one individual manufacturer, but it might well be that the rubber or scrap now eked out for all non-priority consumption is of such low grade that nothing better can be done with it. It seems also obvious that the mineral filler is such that there are gas-producing components present or is so hygroscopic as to give the sponge-like effect on heating. One might then suspect absence of chemical control in the factory, or what appears more likely, the rough hand of the Ministry of Supply or the Rubber Controller. It is interesting to note that the poor rings are sold in batches of 12, without a packet and without the name of sales organization or manufacturer. Obviously, somebody has learned the value of the old saying: " No names, no pack-drill."

It seems a pity, therefore, that the culprit is not made to carry out a series of bottling experiments with his own rings. He would then understand some of the conditions under which the housewife now works. She undergoes not only the unpleasant experience of having to find the aforesaid bottles, rings and precious sugar, but is also faced with almost certain failure in a number of her bottlings.

This must not be regarded as an attack on an enemy industry. Rubber, indeed, is in a sister industry and is as " plastic " as any we can show—it is only the existing economic set-up that separates rubber from our own industry. Moreover, we ourselves can give a few examples of poor quality plastics that have been foisted on an unsuspecting public in the past. We merely wish to stress that the prohibition of manufacture or sale of such low-class goods or production of a much smaller quantity of good quality material would serve the country better.

NEW PLASTICS JOURNALS

Two new journals appear in the plastics world. It is an event on which we may congratulate ourselves, for it is the clearest indication of the importance of the industry.

" Australian Plastics " gives us especial pleasure because we have always felt the need of a native journal to reflect progress in the Commonwealth where plastics development has been so proficiently organized. This is especially so since we remember the birth and the early death in Australia more than 10 years ago of one of the brightest of plastics journals. " Australian Plastics " is edited by Mr. R. D. Cooper; its first number is full of good things and of high promise. We hope to make abstracts from it on a future occasion. It is published at 310, George Street, Sydney.

" Industrial Plastics " is American and a stable companion to the already famous " Tool and Die Journal," one of the Huebner issues from 2460, Fairmont Boulevard, Cleveland, Ohio. The latter journal has always hitherto published a special section on plastic tools and dies, so that in effect the new journal is its lusty self-supporting offspring. In conformity with its parentage it is beautifully printed and is packed full of practical articles on tool design, maintenance and new processes illustrated with excellent drawings.

We offer our heartiest congratulations to Mr. Paul L. Reed, the Editor.

A New Process for Bonding Thermosetting Plastics

A DIFFICULTY in the fabrication of laminated or moulded products of the phenolic or urea types has been the lack of a cement which would give a strong, permanent bond without the necessity of using heat. This difficulty has now been overcome by a simple technique worked out in the Research and Development Laboratories of Bakelite, Ltd. The method consists, briefly, in abrading the surface to be bonded in the presence of a solution of a special phenolic resin before applying the appropriate cold-setting cement, and ensures that the joint is stronger than the material to be bonded.

Prior to the development of the Bakelite "wet abrasion" process, joints which were sometimes sound were made by dry abrading the surfaces before cementing. Since no reliance can be placed on such joints, this technique can never be used satisfactorily in production. At the best, such methods have been used for sealing purposes and for augmenting other fixing devices, such as screws and bolts. The advent of this new process has simplified the fabrication of phenolic and urea plastic products and offers great possibilities of extending their spheres of usefulness.

The wet abrasion process is eminently suitable for bonding phenolic or urea laminated sheet, mouldings, cast resins and impregnated wood, either to similar materials or to wood. It is impossible to give absolute figures for the bond strength which will be obtained with these materials, because the strength of lap joints is very largely dependent on the amount of overlap and the thickness of the material bonded, so that only a nominal failing shear stress can be quoted. In general, this nominal shear

1
TYPICAL FAILURES WITH DRY LAPPING PROCESS. SHEAR FAILING STRESSES 650 AND 575 LB./SQ. INCH
2
TYPICAL FAILURES WITH WET LAPPING PROCESS SHEAR FAILING STRESSES >1040 AND >1030 LB./SQ. IN.

Fig. 1.—Test pieces 1 and 2, showing difference between dry and wet lapping.

stress decreases with increase in overlap, and increases with increase in thickness. For instance, a single lap shear joint with an overlap of 1½ ins. and a material thickness of $\frac{3}{16}$ in. will give an average failing stress of 1,000 lb./sq. in. A single lap test piece with an overlap of $\frac{9}{16}$ in. and a material thickness of 9-32 in., will give an average failing stress of 2,500 lb./sq. in.

When single lap test pieces are used, a considerable amount of bending takes place, due to the eccentric loading. In order to reduce this a three-piece test piece can be used, but again this suffers from the defect that it is rarely possible to get even stress distribution. The illustrations show typical failures for various types of test pieces; 1 and 2 (Fig. 1) show the difference between dry lapping and wet, when the dimensions of the test piece are: overlap 1½ ins., thickness of material $\frac{3}{16}$ in. A three-piece test piece is shown in 3 (Fig. 2); dimensions—overlap $\frac{3}{4}$ in., thickness of material $\frac{3}{16}$ in., and 4 (Fig. 2) shows a similar test piece where strips of aluminium foil have been inserted in the joint to give a gap of .003 in. Some figures for such joints are given below:—

Test piece Bakelite Laminated Grade F.5581. Three pieces. Overlap ¾ in., thickness of material $\frac{3}{16}$ in.

Gap	Shear strength
Pressure joint	1,750 lb./sq. in.
.003 in.	1,700 lb./sq. in.
.0055 in.	800 lb./sq. in.
.013 in.	630 lb./sq. in.
.035 in.	490 lb./sq. in.

Gap joints should be avoided, however, since a failure often occurs because the cement has run out of the joint.

7 (Fig. 3) shows another two-piece test piece, where the two outer surfaces are wood and the central portion is fabric-laminated sheet. It will be seen that the failure is essentially a failure of the wood.

For all the above tests spring-loaded clamps were used to apply pressure. It is not necessary to use great pressure,

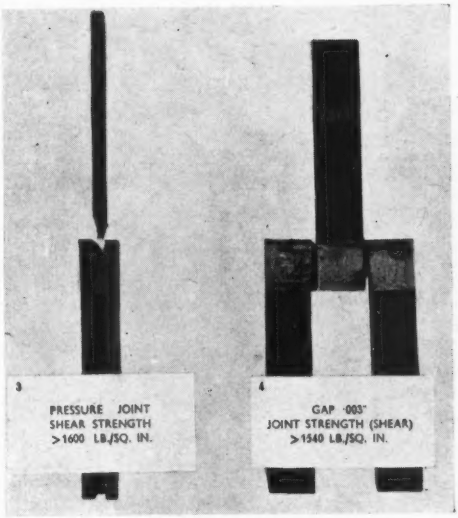


Fig. 2.—Test pieces 3 and 4.

and only sufficient should be applied to prevent the formation of thick films of adhesive in the joint.

Butt Joints

In order to obtain some idea of the true value of the adhesion obtained, a series of tensile tests employing butt joints was carried out. Results of these tests on butt joints made with and without the use of the wet abrasion process are as follow:—

Material: Bakelite Laminated Sheet F.5581.

Control test (with dry abrasion).

Specimens	Failing tensile stress (lb./sq. in.)	
1	1,360	Average: 1,171
2	535	
3	1,860	
4	930	

Tests (with "wet abrasion" process).

Specimens	Failing tensile stress (lb./sq. in.)	
1	3,140	Average: 3,882
2	4,200	
3	3,640	
4	4,550	

6 (Fig. 3) shows one of the test pieces.

Joints made without any abrasion of the surfaces are weaker than those obtained in the control test.

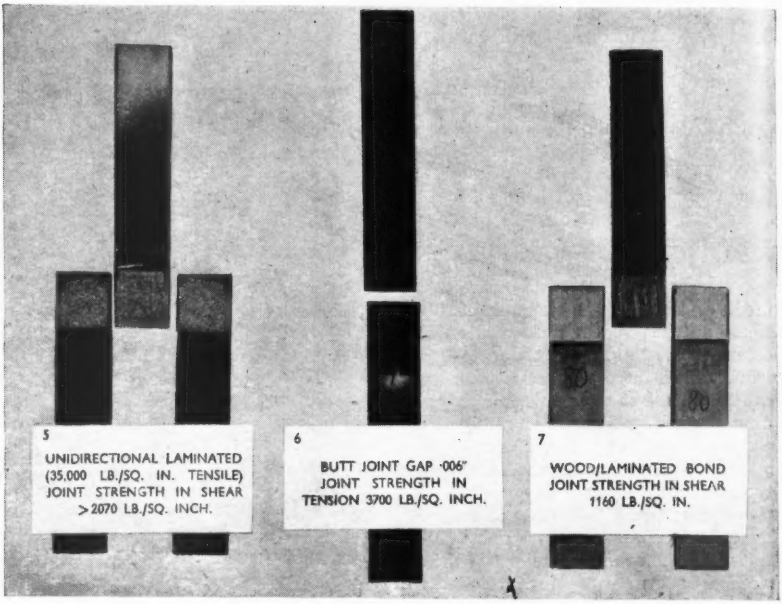

5
UNIDIRECTIONAL LAMINATED (35,000 LB./SQ. IN. TENSILE) JOINT STRENGTH IN SHEAR >2070 LB./SQ. INCH.
6
BUTT JOINT GAP ·006" JOINT STRENGTH IN TENSION 3700 LB./SQ. INCH.
7
WOOD/LAMINATED BOND JOINT STRENGTH IN SHEAR 1160 LB./SQ. IN.

Fig. 3.—Test pieces 5, 6 and 7.

When tested in shear, joints made by this process invariably fail outside the cement line and the criterion of failure is the shear strength of the material. Joints, aged for seven months have given failing stresses equal to or greater than the original figures.

Boiling tests have been carried out by immersing the joints in boiling water for 3 hrs. The test pieces used were similar to those shown in 3 (Fig. 2), and a reduction in average failing stress from above 1,700 lb./sq. in. to 1,300 lb./sq. in. resulted. While this drop is considerable, it must be realized that this test is very severe, and probably the joint would recover most of its original strength when dried out.

Preparation of Surfaces

In carrying out the process, the surfaces to be bonded are abraded in the presence of Bakelite Activating Solution J.11180. Abrasion may be carried out, using a wire brush, scraper or abrasive paper or cloth, used by hand or mechanically. The surface film must be completely removed in the abrasion process, and both surfaces to be bonded must be treated, except where wood is one of the surfaces, abrasion being unnecessary in the case of this latter material. When the surface film has been removed, the abrasive mixture should be wiped off and the prepared surfaces are then in an active condition, which will ensure a strong bond when they are finally cemented. Surfaces so treated will retain their activity for some weeks, but it is preferable to carry out the bonding within a week.

The actual bonding operation follows the normal technique employed with cold-bonding processes.

The process is particularly applicable to laminated plastics and to densified woods.

Further information is available from: Bakelite, Ltd., 18, Grosvenor Gardens, London, S.W.1.

TECHNICAL LETTER FROM U.S.A.

By A. J. WARNER, B.Sc. (Lond.)

Synthetic Linear Polyamide Extrusion Compounds

We have arranged with Mr. Warner to supply us, as regularly as is possible, with certain technical developments in America which he regards of special interest to our readers. Mr. Warner, who will be remembered in this country especially for his work on polystyrene, is now resident in the U.S.A., and has taken up an important technical post there.

AMONG the latest developments in the field of synthetic linear polyamides are the special nylon plastic types developed by the E. I. du Pont de Nemours Company, Incorporated, for use as extrusion compounds for wire.

As is well known, nylon has been widely used in the form of yarn filaments and bristles. More recently injection moulding compounds have come into industry prominence. The development of special formations for extrusion on wire and cable rounds out the industrial significance of these materials. Two outstanding properties of the compounds are their abrasion resistance and toughness and their ability to be applied in very thin wall thicknesses by the use of conventional plastic extruders utilizing special screen set-ups and tip and die construction. Other useful properties include a slow rate of burning and a higher softening temperature than the majority of wire-coating materials. Nylon is also reported to be fungus resistant.

Among the wires currently being produced on a semi-production basis are radio hook-up wires where the nylon is extruded over a vinyl chloride or vinyl chloracetate insulation; and infantry wire where the nylon is extruded over a special polythene insulation. The temperature of the compound at extrusion is 450 degrees to 475 degrees F., at which temperature the nylon is liquid. It is essential to have the feed section of the extruder cold during the extrusion, while the screw should not be cooled but allowed to reach the temperature of the extruder.

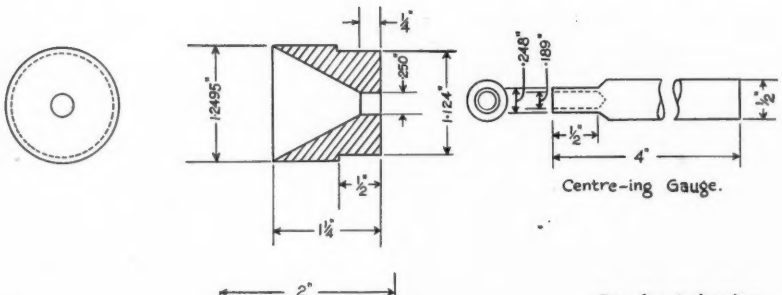
The screen pack recommended consists of 20, 60, 120, 120, 60 and 20 mesh screens in that order. These are necessary because during extrusion at high production rates unmelted nylon particles tend to be carried through the extruder, in the molten material, and these cause " lumpiness " of the wire covering unless prevented from reaching the die.

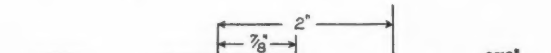
The wire guide should be some 0.010 to 0.012 in. diameter greater than the wire to be covered. The tip should have a land about $\frac{1}{16}$ in. longer and all edges should be sharp and free from radii. A typical set-up is shown in the attached illustration.

The nylon is extruded in the form of a tube which is drawn down on the wire. Setting of the extruded nylon is accomplished by means of a cold-water trough which is brought to within 1 ft. of the extruder die. To insure an improved fit of the nylon jacket on the wire insulation, a slightly reduced pressure is applied at the back of the extruder head. For radio hook-up wires using a vinyl insulated wire, nylon extrusion rates of 800 to 900 ft. per minute are common in production, and even higher speeds have been obtained in certain cases.

The use of such wire extrusion speeds, coupled with the low screw speed necessary with the small amount of nylon being extruded, necessitates changing the gear ratios between the screw and capstan on the majority of machines, but apart from this change most conventional plastic extruders require little modification for the satisfactory running of nylon.

Should it be required to shut down an





Die for jacketting wire with nylon, for No 2 Royle crosshead.

extruder for a period of up to 2 hrs., it is not necessary to clean out the machine, because of the thermal stability of these special extrusion grades.

The head of the machine should be cooled down to freeze the nylon, and the feed hopper should be filled with cold stock to prevent air from reaching the molden material in the screw and breaker plate portion of the extruder. On restarting the machine, it is ready to operate when the compound reaches the correct temperature.

Overnight shut-downs will not hurt the material provided the machine is heated before starting up again; the machine should be brought to temperature and purged with fresh nylon. A recommended grade of extrusion compound found to have good stability toward heat, and possessing excellent processing characteristics, is nylon FM-105.

" METHODS OF TESTING FINISHED MOULDINGS "

By B. Shearman, B. C. Fleming-Williams, Z. Rogowsky and D. J. Strong

This report published by the British Electrical and Allied Industries Research Association, at 34s. 6d., describes a series of investigations to ascertain whether tests usually carried out on moulded materials with standard test-pieces could be made on miniature specimens cut from finished mouldings. The work was done at the request of the British Standards Institution with a view to preparing Specifications to cover such tests as distinct from those on moulded materials.

Methods of cutting the mouldings are discussed and specimen sizes are suggested. Tests which could be applied to specimens obtained from mouldings were evolved for impact strength, cross-breaking strength, crushing strength, electric strength, surface resistivity, plastic yield with temperature, resistance to heat (glowbar), specific gravity and water absorption, and are described. The results obtained by these tests are compared with those of standard tests to see how far correlation is obtained, and tentative conclusions are drawn. Although suggestions are made for further work, it is desirable that this should be deferred until some experience has been gained on the use of the technique by interested parties.

LETTERS TO THE EDITOR

Silicone Resins

In your kind review of my book "Modern Plastics" in last month's issue you expressed some surprise at my omission of silicone resins. Your comment was that ". . . for the silicone resins, one year after he writes, have become of important industrial value." The implication is that at the present time silicone resins are well established and in widespread use—even in this country. How I would like to agree with you. But the facts are quite different. The only difference between June, 1944, when I wrote the preface to my book, and now, is that people here are conscious of silicone resins and have some information about them. Before, they were blissfully unaware of them.

The widespread interest in this country has developed largely as the consequence of an extravagant article which appeared in a popular magazine towards the end of last year, a magazine which business men read on long train journeys. It is another outstanding example of the brilliant manner in which the Americans put new materials "across" and create a new market.

What are the facts about silicone resins? Is there in Great Britain at the moment one pound of any usable silicone resin available for sale or sample? Is there any manufacturer in this country who may be able to offer me any commercial silicone resin during the next twelve months? I would be very glad for the information.

I have known about silicone resins for some years. After all, I am responsible for Plastics Development work for one of the greatest electrical concerns in the world. The electrical industry offers the immediate outlet for these materials. So far as access to new plastics is concerned, I have probably been in a somewhat privileged position. Yet what have I seen of silicone resins? I have played with a marble of "plastic putty" which bounced most impressively. I have had half a pint of a silicone resin varnish which did not behave as predicted. One of my friends has "pinched" a tube of silicone grease. Otherwise I have had nothing to work on to check up the striking claims made for these materials. Nor, so far as I am aware, has anyone else in this country.

The two American concerns who make the resins have produced them on a very small scale. Those that were any good have been used for highest priority applications on special U.S. aircraft, etc. Even now production is on a small scale, semi-commercial, the products being available at extremely high cost. They may become very important. But they are not yet.

It would not be right to ignore silicone resins because our own chemical concerns have not yet made any available. But, frankly, in view of our war-time experience, I haven't the heart to reproach them.

I also wrote in my preface: "It is absolutely imperative for the reader to obtain these materials, smell them, handle them, and so on." Since there does not seem to be the remotest chance of the reader obtaining any silicone resins for some years, surely it is justifiable to defer consideration of them for a subsequent edition. In the meantime we can only hope that products of British manufacture will make their appearance at some early date.

HARRY BARRON.

[EDITOR'S NOTE.—No. It cannot be justifiable merely on the ground that there are no British silicone resins. Science is international.]

The 69 Grenade

Whilst carrying out a search recently for information concerning the spraying of plastics, we noticed with interest the various editorial and correspondence references to the mysterious "No. 69," which was ultimately fully described in your November, 1943, issue.

Our attention was drawn particularly to the remarks contained in this latter article concerning the fuse used in the No. 69 Grenade, which occurs on page 501, last paragraph: "With such a construction it can be claimed that the fuse has been made possible only because it can be moulded in plastics."

We think it may interest you to know that the fuse mentioned is, in fact, a slightly modified version (modified to suit its construction in plastics) of the No. 146 Fuse invented by the chairman of this company, Mr. A. H. Midgley, M.I.E.E., in 1916, and used for initiating the bomb of the Stokes mortar. Some 10 millions of these fuses were made in the last war, of which Mr. Midgley was responsible for making eight millions, in his capacity of chief engineer of Messrs. C. A. Vandervell, Ltd., of Acton.

The question of applying this fuse to the

Mills grenade was discussed in 1918, but work on these lines was not carried out.

We are not clear as to the reason for the strict secrecy concerning the No. 69, but can only assume that it was because of the plastic construction. The fuse was known, as we have mentioned, and the Mills grenade was used to effect in 1914-18. On the other hand, the Germans were not ignorant of the possibilities of using plastics for armaments, so why the secrecy?

Even if special detonators or explosive filling were used in the No. 69, a disclosure at an early date of the construction would not have given away any secret in this respect. But it would have been of undoubted value to others interested in plastics, as indicating the extent to which their industry was helping in the war effort.

For your information we are enclosing a copy of a booklet published by the Stokes Gun Co., in which the No. 146 Allways Fuse is illustrated on pages 22 and 23, and also a copy of Patent Specification No. 112633, which discloses the date.

MIDGLEY, HARMER, LTD.

London, W.3.

AMERICA AND BRITAIN

I chanced to read over your article on "Plastic Tools and British Publicity," and I must agree with you on certain phases of your Editorial which appeared in your March issue. But I do believe that we in the United States, as well as you in Great Britain, are a little too enthusiastic about our own individual nationalism as portrayed in your article. We both seem to be finding fault with each other's mode of living, where possibly a more constructive attitude would be to appraise each other in an "uplifting" sort of way so that we would better understand each other.

We in the U.S. are still all out for war production, and, true, we have glamorized the American womanhood in our advertisements with color and so forth. Our goal is a victory for not only the U.S.A., but for all of the English-speaking world.

Our technical reports have been greatly restricted, as I am sure you must realize, as have yours; but we are going to let this go by the board until secrecy can be lifted.

I believe an overall policy should be of close co-operation between the people of Great Britain and residents of the U.S.A. to form a better understanding of each other rather than a demoralizing form of propaganda to make one faction feel subordinate to the other. CHARLES R. BELTZ.

Fairway Drive, Detroit.

Dear Mr. Beltz,

I admit that there was more than a trace of asperity in my answer to Mr. Carl Martin when I thought that one reason for the difference between American and British technical journals to be the fortunate situation of the U.S.A. regarding labour, paper (we are still cut down to 21½ per cent. of our pre-war consumption) and the respective attitudes of our two war-time Censorships. A good example is resuscitated by Midgley, Harmer, Ltd., whose letter is also published on this page. It was only after "Modern Plastics" in the U.S.A. had published an excellent article on Canadian manufacture of the British "69" grenade that our Censor, hurriedly but grudgingly, gave this journal permission to do so.

In fact, my burst of bad temper was not so much a grouse against American good fortune as an appeal to Government officialdom to remove some of our difficulties.

With your general argument I heartily agree that we are too enthusiastic over our individual nationalisms. But when you use the words "constructive attitude," "close co-operation" and "better understanding" we insist that these abstract adjectives and nouns must be preceded or followed by an interchange of concrete proposals and acts.

During the war we encountered several American concrete facts. Fifty American destroyers when we needed them most. That was "close co-operation." Several million G.I.s in our small island with whom we talked and laughed. That was "better understanding." Lease-Lend, which Mr. Churchill described as "the most unsordid act in history," and millions of tons of food. That is the "constructive attitude" which, if you will permit a mild joke, was something we could get our teeth into.

These were the concrete facts that 40,000,000 Britons encountered and still talk about.

During the war we sent you nothing concrete that I know of—not even an English railway bun that no American could ever get his teeth into.

The fact is, that as a consequence, we have been anxious to tell 130,000,000 Americans that we had done our fair share in this war, and that we have been too reticent or rather too stupid to say so. Instead, the generous statements of Mr. Winant, Senator Pepper and President Truman's recent report to Congress have done it for us. That is true friendship.

M. D. CURWEN, Editor.

COLLOID SCIENCE

The fundamental experiments now being carried out on colloids at Cambridge University are of such importance to our knowledge of the synthetic resins and polymers generally that the following notes on some of the apparatus available at the laboratories will prove of much interest.

WHEN Professor E. K. Rideal, of the Department of Physical Chemistry at Cambridge University, agreed to the request of the committee of the Birmingham and Midlands Section of the Royal Institute of Chemistry to arrange a course in Colloid Science, it was thought that possibly 50 members might apply. There were 200 applications, so the course (held last month) was divided in two, and the work of all the lecturers and demonstrators was doubled in consequence. The arduous work of the lecturers may be gauged from the fact that lectures started at 9 in the morning and carried on, with short breaks, until 9.45 at night. There was practically full attendance at every lecture. The subjects, all having a bearing on plastics, ranged from the thermodynamics of colloidal systems to modern conceptions of the interface in emulsions and foams.

Besides the lectures, there were practical experiments and visits to other laboratories in Cambridge, such as the Cavendish Laboratory, containing the £5,000 R.C.A. electron microscope, where magnifications of the order of 25,000 diameters are possible compared with 2,000 diameters for the highest-powered optical instrument. This extraordinary magnification, where it is possible to photograph some of the larger molecules, is achieved by substituting magnetic fields for glass lenses and showers of electrons for the ordinary light waves. This massive instrument, some 8 ft. high, examines a minute tenuous film of substance a millimetre or so square. Our insight into the structure of matter is being rapidly enlarged by the electron microscope. The full extent of its usefulness as well as the information which is still forthcoming from the diagrams is not yet known. The extraordinary photographs of polystyrene, with some adhering carbon widely publicized a short time ago (see "Plastics," June, 1944), give an idea both of the clarity and the detail work which it is possible to obtain with this machine.

A further instrument capable of yielding much information on the structure of organic compounds is the infra-red spectroscope. It is well known that the normal spectroscope is capable of detecting elements present in quantities so small as to be impossible of detection by straightforward chemical methods. It is used, for instance, in astronomy and stellar chemistry is entirely spectroscopic chemistry. The infra-red spectroscope goes further. It enables definite groups and radicals to be identified with speed and certainty. The manner in which the interatomic forces act within the molecule is indicated, and the following chemical bonds, OH, CH, NH, SH, as well as groupings involving double and triple bonds, e.g., C = C, C = N, C = C, C = O, may be detected. It is hoped in the future to carry out work on the infra-red absorption of specific colloidal systems and on the use of polarized infra-red radiation.

The X-ray diffraction apparatus is yet another instrument which has given us an enormous insight into the structure of matter: demonstrating that many plastic materials which used to be considered to possess a completely amorphous structure are, in fact, crystalline. A stream of X-rays is directed against a small fragment of the material held on a rotating platform in front of a fluorescent plate. The very short wave-length X-rays penetrate the crystal and are reflected by the minute faces regularly as the crystal revolves. These spots of X-ray light trace a pattern on a photographic plate (which is inserted in place of the fluorescent screen), and a mathematical

study of the pattern enables the nature of the crystal to be determined.

It is probably little realized in the plastics industry how closely its work and its processes are studied and investigated by the Colloid Science Laboratories at Cambridge. For instance, a highly elaborate technique has been developed for studying the thermal degradation of high polymers. One apparatus consists of a large glass evacuated globe containing a small electric furnace, suspended over which is a tiny container holding a fragment of the synthetic resin or rubber to be studied. The container may be weighed with great accuracy and lowered into the furnace without disturbing the vacuum. The products evolved on heating can be drawn off and analysed.

There are, all told, some 30 workers in the laboratory studying problems such as the heats of mixing in relation to polymer/plasticizer interactions. Extremely minute temperature differences are measured by means of a special apparatus immersed in an accurately temperature-controlled water bath. When a true plasticizer is mixed with resin, a small quantity of heat is slowly liberated. The greater the quantity of heat liberated the better the compatibility. It is hoped at the conclusion of this investigation to be able to predict with accuracy which plasticizer will be best for any given polymer of known structure. The normal laborious series of experiments which runs into many months would be transformed into a calculation capable of being performed in a very short period.

Molecular Weight Determination

The ultracentrifuge is an instrument designed, among other purposes, for the determination of molecular weights as opposed to molecular structures. It might be thought that the greater the relative weight of a molecule the more easily it could be determined. The contrary is the case, the weights of large molecules, especially of substances such as proteins, being extremely difficult to ascertain. The relative weight of a molecule of hardened casein, for example, is still unknown.

By utilizing a centrifugal force of the order of a half a million times that exerted by gravity, a mixture of molecules of assorted sizes may be separated out into a series of consecutive layers, with the biggest on the outside and the lightest in the middle, and molecular weights of from 10,000,000 down to 17,000 thus determined. A massive machine is necessary to exert such an enormous force and precautions must be taken against bursting. The apparatus measures about 6 ft. by 3 ft. by 3 ft., and is protected with 6-in. concrete walls, as the rotor swirls round at 1,600 revs. per second. The quantity of material used is as minute as the ultracentrifuge is huge. One or two drops (0.25 c.c.) are inserted in a tiny transparent cell, which is spun for perhaps three or four days to secure complete sedimentation. Refractive index measurements are made as the machine is in motion. Recently the taking of readings has been speeded up very much by means of using a recording pen, diagrams being obtained directly. These are facilitated since the tiny rotor is airfloated instead of being on bearings with all their mechanical difficulties, as in the Svedberg centrifuge. The rotational movement is secured by turbine principle, air jets being directed against the rotor. The speed is measured by a 1-in-10,000 reduction gear.

Langmuir Trough

One of the most useful tools ever devised for the study of surfaces and the changes which occur there is the trough designed by Langmuir, in America, and modified by Professor N. K. Adam in this country. The general layout of the Langmuir-Adam trough is shown in Fig. 1 overpage. Besides being useful for the determination of surface potentials and surface viscosity, it may be used for measuring the length of molecular chains, the changes which occur on compression of a film and the orientation of molecules. According to the end in view so the technique of operation is modified, but, in general, a mono-molecular layer is deposited from a solution on to water contained in a trough.

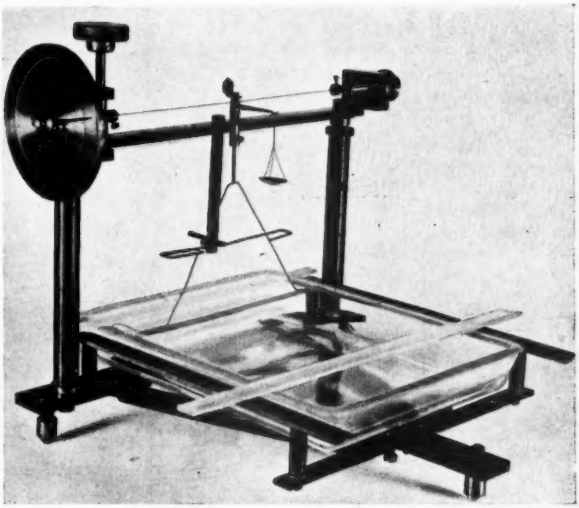


Fig. 1.—The Langmuir-Adam Trough.

This surface film may be compressed by means of a simple glass slide aganst a floating mica barrier, the pressure being indicated on a sensitive scale. A micrometer syringe is used to give a precise volume of known strength solution on the surface of the water. The solvent in the solution evaporates, leaving the substance as a monomolecular layer on the surface, the area of which is found by pushing the glass slide until a pressure begins to be exerted on the mica barrier. Knowing the weight and area, the thickness of the film is a matter of simple calculation. By means of this instrument it can be shown how resin molecules associate to join bundles of micelles and how certain fatty acid films stand up on their " tails " on water when compressed and lie down when unrestrained.

These phenomena may be used to modify rates of reaction, to study the differences which result from polymerization of any given material in the mass as opposed to that in an emulsion. The precision and utility of the Langmuir-Adam Trough is so great that it is certain to be found in every important plastic laboratory within the next decade or so.

There is little space left in which to describe the other elaborate instruments by means of which the properties of plastics are measured, their structure determined and their reaction predicted, but mention must be made of the Covette Kinetic Viscometer for the measurement of streaming birefringence. This phenomena is related to that of thixotropy, so important in the study of plastic substances such as paint systems. When a collection of large non-symmetrical molecules, e.g., aluminium naphthenate, are subjected to a strong shearing action the molecules set themselves like trailing weeds in a stream, with the consequence that their properties are different in different directions. The change in optical properties are the most apparent and the most easily studied. The Covette viscometer consists of two opposing rotating surfaces with the fluid to be studied between them. The change in optical properties is plotted against the rate of shear.

The last instrument to be described is the huge apparatus for studying photochemical reactions in monolayers with ultra violet light which, as is well known, strongly promotes a variety of chemical actions. The whole optical system is of quartz, ordinary glass being opaque to U.V. light. It contains the largest quartz crystal in Great Britain, found on a scrap heap in Germany just before the war and brought to this country and cut. We cannot speak too highly of this endeavour to bring the plastic industry into closer touch with " pure " research.

World's Industry Employs Plastics

GENERAL ENGINEERING

Plastics in engineering formed the subject matter of a paper read by E. M. Elliot before a recent meeting of the Glasgow Section of the Institution of Production Engineers. The properties of the thermosetting resins were discussed in relationship to their present uses and future development ("Journ. Inst. Prod. Eng.," 1945/24/163). High-precision plug and ring gauges made of sintered hard metal by A. C. Wickman, of Coventry, are provided with handles or holders in plastic. Phenolic resins are largely used, but for the holder taking "go" and "no go" rings, perspex is employed. It is claimed that this material has a suitably low heat conductivity and high shock-absorbing capacity ("Machinery," London, 1945/67/103). **Fabricating methods for Lumarith,** celluloid, methyl-methacrylate and other non-cellulose thermoplastics are considered in a well-illustrated brochure by Celanese Plastics Co., New York 16, N.Y. Cutting processes dealt with are: blanking, sawing, routing, drilling, reaming, tapping, lathe and screw operations. Data on fabrication of film stock, finishing operations and moulding processes are also given. **New laminated-plastic Ferobestos,** containing various forms of asbestos as base material, is described by Paterson. The material has high chemical resistance and seems to be suitable for bearings as it does not place high demands on lubricants ("Machinery Lloyd," 1945/17/70). **Press tools,** consisting of steel strips, or rules, fixed in impregnated laminated-wood mounts, are described in an illustrated article in "Production and Engineering Bulletin," 1945/4/259). These tools, which are the subject matter of patent applications, have been developed by a concern engaged in aircraft production. **New type of plastic tubing,** light amber in colour and semi-transparent, is made of a copolymer of vinyl-chloride and vinyl-acetate. The "Plastubing" is very useful for chemical laboratory work, as tight connections with glass tubes can be made if the diameters fit; no tendency to split when pushed on to separated connections exist ("The Laboratory Fisher Scientific Co.," 1945/15/7, No. 4). **Abrasive wheels of synthetic rubber "Hycar"** have been developed, with these, under constant conditions, the output in sawing manganese-bronze castings has been almost doubled. In another test, the synthetic rubber wheel cut aluminium-bronze castings with a wear of 0.43 sq. in. per square in. metal cut, the same figure for the natural rubber wheel is 0.627, i.e., 45 per cent. more ("Scientific American," 1945/172/306, May). **Wood as an engineering material** is examined in a recent account by Cady. Wood is an almost inexhaustible material and wood waste is reduced considerably by modern processes, for instance by mechanical barkers and the utilization of saw dust and other wastes in pressed wood, etc. Forms of wood used in numerous industries, their characteristics and manifold uses are very adequately described ("Metals and Alloys," Vol. 21, 1945/21/980). **Sapphire plug gauges,** which are of great wear resistance, are provided with handles from hexagonal Tenite produced by extrusion ("Scientific American," 1945/173/114). According to "Plastics World," Feb., 1945, the National Rubber Machinery Co. has placed on the market a bench extruder and wire coverer capable of handling 6-7-lb. charges.

AIRCRAFT

New structural material for aircraft consists of cross-laminated glass-plastic cloth with honeycomb core. Its specific gravity is only 1.75 and the specific strengths already surpass those of the 24ST aluminium ("Autom. and Aviat. Industries," 1945/93/32). **Plastic enclosures for aeroplanes** are produced by various methods such as free-blowing, vacuum forming, etc. Satisfactory optical results can be expected from almost any contour. Principles of optical testing have been given by Th. Gladwin ("Aviation," Vol. 44, 1945/44/147). **"Papreg," a new paper-base laminate used in aircraft** and other stressed structures, resulted from research at Forest Products Laboratory. It has twice the tensile strength and improved mechanical properties compared with the best earlier paper-base laminates. It lends itself to low-pressure moulding techniques and can be formed to moderate double curvature without special treatment. E. C. O. Erickson and G. E. Mackin review this material in "Transact. ASME," 1945/67/267.

MOTORS

New-type cushion support for latex cushioning material will incorporate the principles of leaf-spring design into seating. ("Autom. and Aviation Ind.," 1945/91/90). **"Automotive Plastics"** are reviewed in a well-illustrated article ("Scientific American," 1945/173/83). The 1942 Oldsmobile models list 32 plastic components from which 25 are of cellulose acetate, five methacrylate, and one each of butyrate and urea resin. The same issue contains a Review on "Automotive Rubber," based on a paper by E. F. Riesing read before the Society of Automotive Engineers.

ELECTRICAL

To reduce accidents, **plastic connectors for current-carrying wires** are made in red Vinylite Plastics, whereas those for grounded wires are left white ("Scientific American," 1945/173/24). **Satisfactory design for rotor,** including several metal parts, such as slip-rings, copper leads, lugs and mounting inserts, has been obtained by a transfer moulding process; a high-strength and impact macerated-fabric phenolic material is used ("Product Engineering," 1945/16/458).

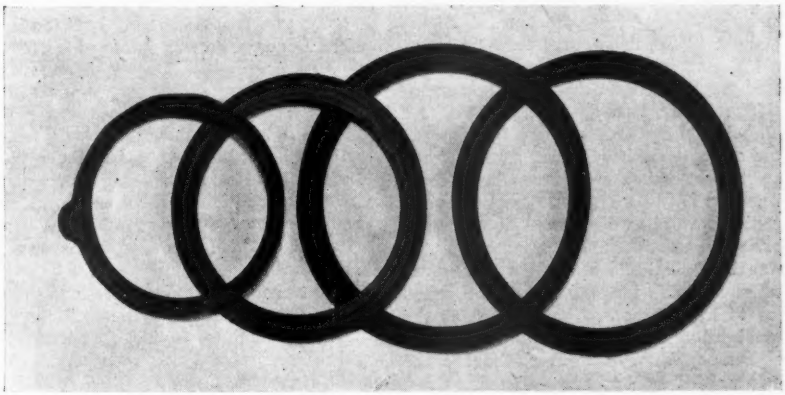
MISCELLANEOUS

New "Natvar" tubing on vinyl basis showed no deterioration or increased stiffness when subjected to an oven temperature of 257 degrees F. for 800 hours. After ½ hour at 380 degrees F. slight flow occurred, and after returning to room temperature the tubing regained its flexibility. Tubes are flexible at temperatures ranging down to −80 degrees F. ("Machinery," N.Y., 1945/51/184). **Reference book sheet on the physical properties of cellulose plastics** contains valuable diagrams showing the relationship between flow temperature and physical properties such as tensile strength, elongation, flexural strength, compressive strength, Brinell and Rockwell hardness, impact strength, deformation under load. All strength properties improve with increased flow temperature (injection, compression and extrusion),

with the exception of elongation, deformation under load and impact strength (" Product Engineering," 1945/16/503). **Thread guides of synthetic sapphires** produced according to a special method are embedded in a plastic matrix to fit existing textile machinery as substitute for ceramic type guides (" Product Engineering," 1945/16/229). Besides being employed for protection against corrosion, a **plastic dip coat is used for cushioning carbide-tipped tools and machined parts** from chipping and abrasion whilst in store; a further important application is for packing (B. Gould in " Iron Age," Vol. 155, 1945, pp. 66, 67, June 14). **Intrinsic viscosities and osomotically estimated number-average molecular weights** of a series of cellulose-acetate fractions have been measured by A. M. Sookne and M. Harris, of the National Bureau of Standards. The same scientists investigated the tensile strengths, ultimate elongations and folding endurances of cellulose-acetate fractions and blends. W. J. Taylor, J. M. Pignocco and F. D. Rossini have developed a novel method for calculating the properties of hydrocarbons (" Technical News Letter," May, 1945, p. 37). **Radio masts for the U.S. Signal Corps** are made of plywood sections, which can be rested in a compact box when dismantled. After impregnation with urea-formaldehyde resin the layers are wrapped spirally on a mandrel so that some veneers are parallel to the axis, some at right angles and some at 45 degrees. Thus the plytube attains maximum strength (" Scientific American," 1945/173/86). **Creep properties of thermosetting phenolic resins** have been studied by W. J. Gailus and D. Telfair (" Transact. ASME," 1945/67/253). The test temperature was approximately 192 degrees F. Tension creep data are reported up to 1,000 hours and recovery data up to 250 hours. Modulus-of-elasticity values were obtained at the beginning and end of the 1,000-hour tests. The effect of moisture content on creep properties was also studied. T. S. Lawson and H. K. Nason (" Transact. ASME," Vol. 67, 1945, pp. 259-266) studied the effect of outdoor exposure (Florida and Massachusetts) on tensile properties, impact strength, optical properties, and shrinkage of cellulose-acetate and cellulose-nitrate sheet. The effect of outdoor exposure on the composition of these plastics and on the molecular weight of the base cellulose esters is shown quantitatively. Data on moisture pick-up and dimensional change after immersion in water are given. **Horseshoe permanent magnet fixed to a thick sheet of Plexiglas** acts as protection to machine operators, deflecting flying fragments of steel (" Scientific American," 1945/173/86). **Production of water-, fire- and mildew-proof duck** for army tent cloth was made possible by the use of synthetic resins. Formerly 20 per cent. of all goods shipped to the South Pacific were destroyed by mildew; the new synthetic resin impregnation makes, however, this cloth resistant (" Scientific American," 1945/175/108). Recent popular article explains the **application of high-frequency heating for the fabrication of large wood laminates** and for preparing plastics for moulding. It permits quick production of large and complicated components (" Scientific American," 1945/173/22). Development in injection moulding is a **uniform coating for wooden heel cores of women's shoes** by applying a cellulose-acetate cover of $\frac{1}{16}$ in. thickness. It is claimed that owing to the injection pressure the material slightly permeates into the wood, so that it does not peel off (" Scientific American," 1945/173/24). Vinylite plastics find varied uses as **protective coatings for tanks for various fluids.** They are used, for instance, to preserve the natural taste in wine and brandy, they keep aviation gasoline stored in concrete tanks free of contamination. Most interesting is the use in tanks of clippers alternatively used for fuel oil in the trip to the fishing grounds and filled with refrigerated salt brine and fish on the way back. The alternating exposure to these fluids of different type and temperature seems to be a very severe test for a coating (" Scientific American," 1945/173/50). **New application of Nylon is for paint brushes.** This is considered to be the most significant advance of this industry in the past 25 years. (" Machinery," N.Y., 1945/51/171.)

The Mystery of the Crimson Rings

A Tale of Horror and Despair



A Circa 1939. B Circa 1941. C Circa 1943. D Definitely 1945.

"POGSON," said Philo (Wimseycal) Bones, as he sipped his nightcap of Huddersfield port (we should say port-type) laced with three drops of di-methyl sulphate, "did I ever tell you of my first case way back in 1944?"

"Yes," said Pogson, "several times."

The Sleuth at Home

"Well," went on Bones, as he picked up his saxophone and gave a few toots to compose himself, "it was shortly after I had shown my atomic bomb to the Minister of Aircraft Production that I decided to take up criminal investigation and settled here in Candlestickmaker Street. One night the telephone rang and . . ."

Bones never finished his story, for the telephone rang again.

"Yes, Philo Bones here. . . ."

His eyes gleamed. "A life and death matter, Pogson," he whispered. Then aloud. "Yes, come straight round. We'll be waiting."

"Who was that?" said Pogson.

"I don't know," said Bones, "but we'll soon find out."

Enter the Mysterious Stranger

In fifteen minutes Pogson ushered in a tall, handsome man fitted with a large black beard.

"Mr. Bones," he cried excitedly, "you must help me. My wife's disappeared," and he sank into a chair, removed his beard, which wasn't well-fitting anyway, and wiped his forehead.

"Tell me everything," said Bones, simply.

"My name is Dogsboddy," said the visitor, "I'm the Editor of 'Plastics,'" he added modestly. "I needn't tell you what plastics are, of course. . . ."

"Indeed, you may not," said Bones. "I remember I had a cat that accidently knocked over a beaker of formaldehyde on to some cheese in a mousestrap. That, sir, I venture to point out, was the first plastic. But continue."

"My wife has disappeared, Mr. Bones, in circumstances that seem quite baffling," and Mr. Dogsboddy buried his head in his arms and sobbed.

"Pogson," whispered Bones, "I don't like this. Did you notice his shifty eyes? And what is that red splash on his sleeve?"

Pogson leaned over, touched the sticky stain with his finger, looked at it and tasted. "Raspberry flavour," he said.

"Calm yourself, Mr. Dogsboddy," said Bones; "tell me how it happened."

The visitor became calmer. "I'll tell all," he said. "I had had a busy day at the office—callers who were good enough to tell me they were convinced there was a great future in plastics and several geniuses who had discovered a stupendous outlet for sawdust and resin mixtures. I was in the middle of such a conference when my wife telephoned me and asked me to leave at once for our flat as she was bottling fruit. I left at once for home, of course, where I spent an hour or so helping Mrs. Dogsboddy cleaning jars, preparing fruit, and so on, until the jars were put in the oven . . . ."

The All-important Time Factor

"One moment," said Bones, who was taking rapid notes, "what time did you leave your office, what time did you arrive, and did anybody follow you?"

"4.7; 4.28; no," said Mr. Dogsboddy, who was a man of very few words.

"You seem very sure of the time," said Bones suspiciously.

"Yes, I am, Mr. Bones. You see, every day at 4.6 my secretary comes in and asks me whether I want a rock cake or a jam bun with my tea. I left one minute later to-day."

"What," said Bones, "without your tea?"

"Yes," said Mr. Dogsboddy bravely, "I did. There are more important things than tea."

"And what about the time of arrival?" said Bones.

"That can be corroborated by my friend, Featherstonehaugh, who was leaving the flat as I entered. 'Ah,' he said, 'you're early to-day. In five seconds it will be 4.27.' He's a B.B.C. announcer and talks like that."

"Continue," said Bones.

"Well," said Dogsboddy, "I went into my study to write a few editorials for the next number, but I must have dozed off, for I was suddenly awakened by a terrific crash of glass and horrifying shrieks. The outer door crashed to . . ."

"Do you spell that 'to' or 'too'?" asked Bones, who was making his notes.

Plenty of Blood and Poison

"To," said Mr. Dogsboddy. "I rushed into the kitchen, where a ghastly sight met my horrified gaze. Signs of a struggle were evident. Splintered glass covered the floor and there were ominous crimson splashes everywhere. That is all I know. I telephoned you at once, and here I am."

"Mr. Dogsboddy, Pogson, let's go at once. There's no time to lose."

In fifteen minutes (the same time you will notice that it took Mr. Dogsboddy to reach Bones's flat) they were at the Dogsboddies' home. Mr. Dogsboddy unlocked the door and the three walked into the kitchen.

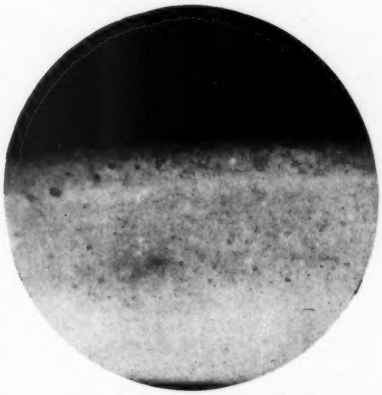
"Yes," murmured Bones, "a grisly sight. Let's get to work, Pogson," he cried. He took some chemical apparatus out of his left-hand pocket and for the next ten minutes was busy analysing, checking and cross-checking in his rapid, methodical way. He found large quantities of silica in the glass, while the red fluid contained appreciable amounts of sugar and arsenic. He also extracted therefrom a small amount of oil and proceeded to estimate its refractive index. When he was finished he turned sharply on Mr. Dogsboddy.

Falsely Accused

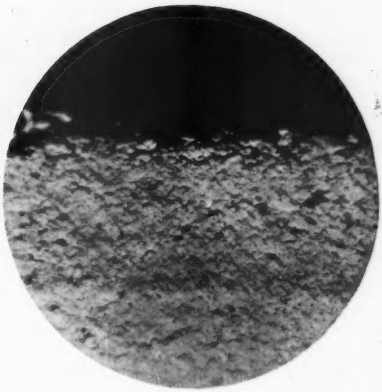
"You were bottling raspberries," he said sternly.

"Yes," replied Mr. Dogsboddy, turning pale. "We managed to get two pounds at our greengrocer's." He added bitterly, "We had to buy eight pounds of potatoes and five lettuces, though, before we could get them."

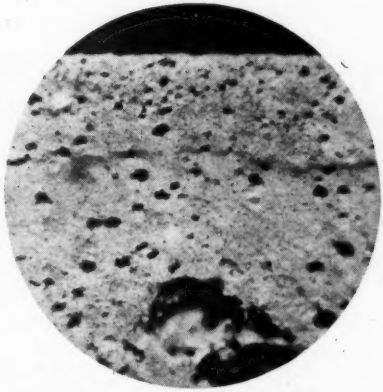
Bones's face softened. "I under-



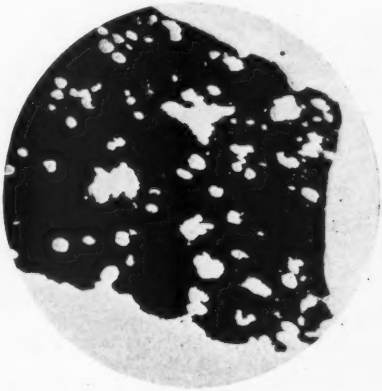
B.—This ring, purchased in 1941, is of excellent quality. A was just as good. Magnification 43.



C.—1943. Rather poorer quality, but in practice not too bad. Magnification 43.



D.—The real culprit of 1945. Both small and large holes give a spongy effect. Magnification 43.



E.—Transverse section of ring D at 43 magnifications, showing shocking condition of structure.

stand," he said. " Well, it's a bad business all right. Did your wife have any enemies? "

" No," said Mr. Dogsboddy, " I'm sure she didn't. Except, of course, she once called the greengrocer an old so-and-so."

" H'm," said Bones grimly, " we'll interview that gentleman later."

" Bones," interrupted Pogson suddenly, " look at these," and he pointed to four rubber rings lying on the kitchen table.

Plenty More Clues

" Don't touch them," shouted Bones. He extracted a pair of long tweezers from his waistcoat pocket, picked up one of the rings with it and looked at it meditatingly. " I wonder," he whispered to himself, " what fell purpose it served." He pulled out a high-powered microscope from his

hip pocket and proceeded to examine the ring at 1,200 magnifications. " Puzzling," he said, " but there's no snake venom on this. What do you make of it, Pogson? "

Pogson, who is a very dull fellow and can never make anything of murders and such like, said " I dunno." He stretched the rubber between his fingers. " Look at the holes in it," he said. " No wonder there's about one chance in five of bottling fruit properly."

" Never mind that," said Bones. " Let us take some fingerprints."

And Now—Murder

Suddenly the silence of the night was broken by the strident cry of a newsboy. " Murder! Shocking murder! Famous rubber ring manufacturer killed in bed! Special! "

" Pogson," shouted Bones, " get a paper." In one minute Pogson was back again. " Yes," said Bones, pointing to the headlines, " he's dead all right. Now we're on the track. Dogsboddy, we must question your wife; where is she? Oh, sorry, you want me to tell you that, don't you? Let's get to work."

Enter the Heroine

There was no need. Suddenly the door burst open and a beautiful female stood on the threshold.

" Dogsboddy," she cried, and opened her arms.

" Mrs. Dogsboddy," exclaimed Mr. Dogsboddy, and fell into them.

" Mrs. Dogsboddy, I presume," said Bones, advancing towards her. " Tell me, has any strange man been following you here? "

" No," she answered, and her colour heightened. " Nobody of importance."

" But, Mrs. Dogsboddy," said Mr. Dogsboddy, " what has happened? "

Justice at Last

" Well, Dogsboddy," said Mrs. Dogsboddy, " you know how playful I become when I find the fruit bottles are not properly sealed. I dashed round to Mrs. Higglethwaite who gets about the same average results and we went and picked up a dozen more friends and set fire to the local Women's Institute where we had been told it was all so easy. By this time we were about a hundred strong and marched up Whitehall and hanged the Minister of Supply and blew up a couple of Ministries. Eventually we got hold of a Parliamentary Secretary and we were about to cut his throat when he promised to put some good rubber or plastic rings on the market. And here I am."

" Well, Pogson," said Bones as they walked back to Candlestickmaker Street, " I think we dealt with that little problem quite satisfactorily. By the way," he added thoughtfully, " I wonder who murdered the rubber ring manufacturer? "

" It was a West Indian sailor," said Pogson, " with a limp in his left leg and a curious tattooed mark on his right elbow. He carried a boomerang. The murder was carried out with a javelin dipped in Black Widow poison."

" Oh," said Bones, suspiciously, " How do you know all this? "

" It was in the evening paper," said Pogson simply.

M.D.C.

The characters in this story are so fictitious and grotesque that any resemblance to living, half-dead or quite dead persons would be so coincidental as to give the author complete protection in a libel action.

The Microscopic Examination of Plastic Materials

Laminated Materials (continued)

By J. H. WREDDEN, F.R.M.S.
(Chief Chemist, Igranic Electric Co., Ltd.)

THE laminated material discussed in the July-August issues was chosen because it embodied material made by two distinct processes, viz., that processed by heat and pressure, forming the core, and that made by heat curing alone, with little, if any, pressure, forming the so-called body portion. Thus we were enabled to examine the structure of both types of material at one sitting, as it were.

Suppose we return to a consideration of the core. We have seen how it is made up of a primary core in the form of a rolled length of "brown paper" on which was built the secondary core; the whole, after curing by heat and pressure, constituting the core proper in the form of a rod ½ in. in diameter. It was previously mentioned that one of the desirable qualities of this material was a good torsional strength figure, and it was shown how the material proved unsatisfactory in this respect. As a result of these discoveries it was decided to look a little more closely into the matter, with a view to seeing what steps could be taken to improve matters in this direction. The results which will be discussed immediately proved quite interesting.

Fig. 16.—Transverse section of paper-base material, showing structure of cruciform primary core, etc. Mag. 10 diameters.

It will be remembered that the primary core structure tended to take up a cruciform cross-section, under the influence of the curing pressure, giving rise to a distinct major and minor axis, the direct result of which was to produce a wave formation in the lamellæ of the secondary core. We saw also how a sharp termination of an axis generated a correspondingly sharp wave in the secondary core, almost amounting to a fold. The net result took the form of two positive folds at right angles to one another, and the direction corresponded to that of the axis responsible for its generation and which continued to the outer surface of the secondary core. It must be remembered that as the fold progresses from the centre of the core to the periphery the fold becomes more and more shallow, so that at the outer surface the fold, as such, has been almost completely flattened. All these observations were made on a transverse section of the round ½ in. core material, and they led to speculation as to ways and means whereby these folds may be deliberately generated and their direction controlled. Thus in a square-section rod produced by the same process, the folds would lie diagonally across the section, tending to increase the torsional

strength of the material by virtue of the fact that a torsional stress applied to such a rod would tend to exert a shear stress across the folds rather than to exert a tensile stress tending to separate the lamellæ, which would be experienced if they were perfectly formed in the manner of a spiral round a circular primary core. The material, of course, has greater strength in shear than in torsion.

The whole question was discussed with the manufacturers of the material, who quickly produced a material, the structure of which exceeded all expectations.

The material consisted of a phenolic-paper laminate of square cross section cured by heat and pressure; this is shown in Fig. 16, which is a photomacrograph of a transparent transverse section of the material at a magnification of 10 diameters. It will immediately be seen that the makers have accomplished the apparently impossible by so controlling the shape of the primary core, which is composed of the same material previously used, that it is almost perfectly cruciform in section, the four arms being roughly of equal length.

The outstanding feature of this structure is the great reduction in the inter-lamellar gaps in this primary body, compared with that shown in Fig. 8 (July issue). This core is seen to be decidedly more compact in structure, a feature which helps to impart strength to the final product. The deep wave formation of the structure built on to this cruciform core is easily seen; at the same time it would appear that this regular core structure gives rise to an increase in the inter-lamellar spaces of the body, for each layer of paper is clearly distinguishable in its structure, the gaps increasing to a maximum at the peaks and in the troughs of the waves. It will be noticed also that the largest of these gaps occurs at the point of origin of the wave, that is to say, at the surface of the primary core, from which point they become successively smaller towards the peripheral surface of the specimen. They are, however, by no means obliterated at the periphery, in this case the wave being still quite pronounced.

The effect of this is easily seen on examining a portion of the square rod when a centrally placed band of clear resin is seen to traverse the length of each side of the rod, thus indicating that the paper surface at this point is sunk below the level of the resin surface. One obvious disadvantage of this arrangement of inter-lamellar gaps is that the largest gaps occur in the position where it is most difficult to cure the resin properly, namely, in the centre around the core, thus it is probable that the actual volume of the material occupied by bubbles is greater in the case of this square rod, with its cruciform primary core, than would be the case of the round rod illustrated in Fig. 8. (See July issue.) The regularity of the structure is, however, a big improvement, the even spacing between paper layers in the body (apart from the peaks and troughs) would, no doubt, tend to produce a more consistent product. When it comes to withstanding stresses, particularly in torsion, the effect of the steep gradient of the positive folds can well be imagined; in this case a torsional stress would be very nearly normal to the sides of these folds, resulting in an almost pure shearing stress in the lamellæ under which conditions, as is well known, a synthetic resin laminate is very strong.

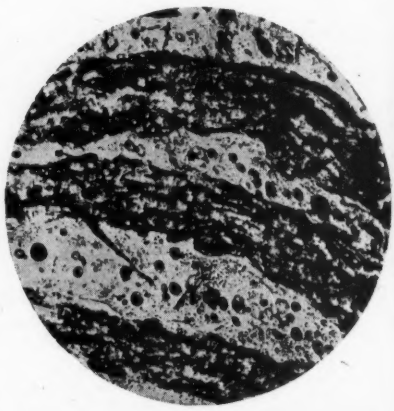


Fig. 17.—Transverse section of generated fold, showing inter-lamellar spaces and bubbles. Mag. 140 diameters.

Fig. 18.—Transverse section of fabric base laminate. Mag. 10 diameters.

The presence of the usual bubbles in the resin, whether due to under curing or not, is quite clearly demonstrated in Fig. 17. This illustration is a photomicrograph of four of the lamellæ in the body material of the section shown in Fig. 16 at the trough of a negative fold; under a magnification of 140 diameters, the large number of bubbles in the resin are quite easily seen, varying in size from dots only just visible to that of the largest of the more obvious ones. The behaviour of the paper will be noticed, inasmuch as it does not seem to have suffered to any appreciable extent, large portions remaining unimpregnated with resin; the ruckling on the inner curved surfaces of the lamellæ will also be remarked.

From the foregoing remarks it will be seen that a great improvement was made on the original pressure-cured material used for the core, and the manufacturers are to be congratulated on developing the control of the processing technique to the level necessary to produce a result so closely approximating to the theoretical conception. It should be pointed out at this stage that as a result of the microscopic study of the first material dealt with (that composed of both the pressure and heat cured laminates) the way was opened up for effecting improvements in the bond between core and body portion, and in the body portion itself, while the study of the primary and secondary cores led to the development of the method of so controlling the pressure curing process that a predetermined primary core cross section could be obtained.

In the same way, the demonstration of the presence of bubbles in the resin, indicating probable undercuring, brought to light a hitherto totally unsuspected con-

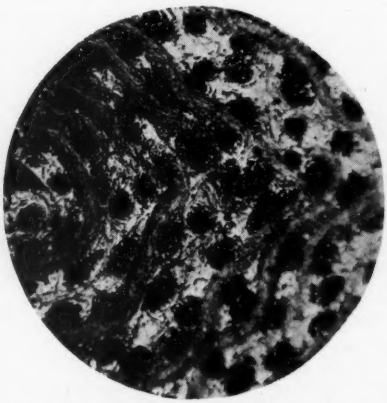


Fig. 19.—Transverse section showing a portion of pressure-cured fabric base square rod. Mag. 70 diameters.

Fig. 20.—Transverse section of fabric base material showing structure of cruciform primary core. Mag. 47 diameters.

dition, as was also the case of the inter-lamellar gaps themselves. In this, of course, we have a very good example of the type of achievement obtainable with the microscope as a control instrument when applied to the manufacture of plastic materials.

However, to revert to our study of the high torsion materials, it was decided to try the effect of producing a linen laminate in the same way as that for the paper material with the cruciform core.

A transverse section of the linen material is shown in Fig. 18 at a magnification of 10 diameters. Here we see immediately that owing to the nature of the linen structure the folds are not so clearly defined, the linen in cross section can be clearly seen; likewise the positive folds generated by the arms of paper core in the centre. A curious effect in the folds is apparent when their shape is studied, it will be noticed how the contour of the fold is not as regular as in the paper material, the sides are almost parallel for above two-thirds of the height of the wave, after which there is a sharp slope on each side, ending in a peculiar but quite definite little hump at the peak of the fold.

If we assume that the weft of the linen runs on a plane parallel to the paper and the warp in the vertical plane, then it will be seen that this shape of fold will be due to the presence of the warp. This will also account for the sharp falling off in steepness of the sides of the waves as it nears the periphery of the section. The wave can be said to possess parallel sides, for only two layers, or at the most three, after which the slope becomes rapidly less, being obliterated at the sixth layer. The structure then becomes a square with its diagonals corresponding to the axes of the

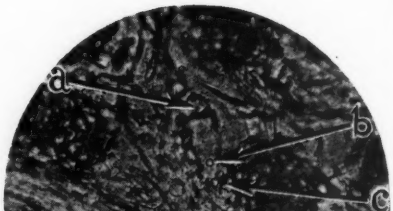


Fig. 21.—Transverse section of peripheral portion of fabric laminate rod. Mag. 140 diameters.

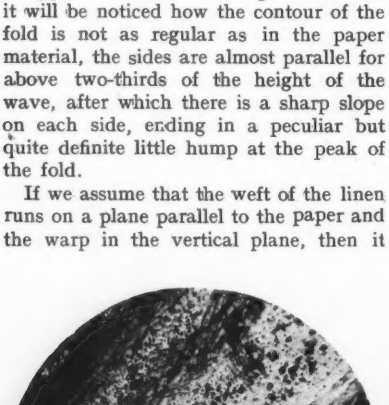


Fig. 22.—Longitudinal section (through A-A, Fig. 18). Mag. 70 diameters.

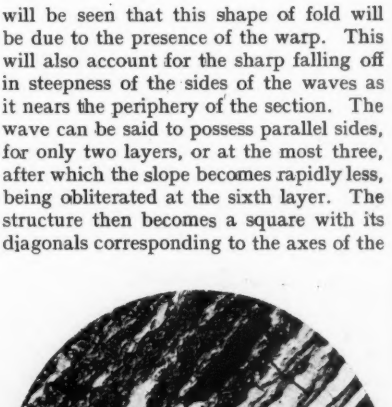


Fig. 23.—Longitudinal section of paper laminate. Mag. 70 diameters.

core. In view of this it is not surprising that this material did not show the expected degree of improvement in torsional strength over the material fabricated from paper only. Furthermore, the degree of impregnation of the base material is less than for paper, in consequence of which the moisture absorption is somewhat higher. It would be interesting to observe the effect of building such a composite material consisting of linen interleaved with cotton paper every alternate layer, or, as a further suggestion, use may be made of an artificial silk material made from continuous solid fibres instead of the tubular staple fibre cotton used in cotton cloths.

A portion of a fold in this material is shown in Fig. 19 at a magnification of 47 diameters, the peculiar contour of the wave is quite clearly seen, together with the tip of one of the arms of the cruciform core. This photograph clearly shows the large amount of interstitial space as compared with the paper base material. The core itself is shown in Fig. 20 at a magnification of 47 diameters; here again the regularity of the structure of the core is well shown, together with the large interstitial spaces in the mass of the material.

Apart from producing a much less regular structure than paper, a fabric base also appears to give rise to greater difficulties when it comes to proper curing of the resin. We have seen that there are numerous bubbles embedded in the clear resin masses of the paper base material even when cured under heat and pressure. In the case of the fabric-based material it would seem that the difficulty of avoiding these bubbles is much increased. This is demonstrated in Fig. 21, which is a photomicrograph of the same section as shown in Fig. 19, but at a magnification of 140 diameters. The photograph shows a portion of the peripheral layers of the specimen, the weft and warp can be clearly seen, together with larger interstitial resin masses containing stray cotton fibres from the fabric and also numerous bubbles. These latter are not very easily distinguished, but some of them are annotated in the illustration. Thus at (a) we have a large bubble, while (b) a single small one and a group of three (about the same size as that at (b)) and (c) the significant point is that in spite of heat and pressure these bubbles exist at the periphery of the rod. This would appear to be due to the nature of the base material, inasmuch as the fabric would possess many more air spaces than the paper; it is also much more difficult to completely impregnate.

In connection with this, it has been the author's experience that using a varnish possessing a very low surface tension, with vacuum impregnating methods, it is still very difficult, if not impossible, to completely impregnate a cotton yarn. Large masses of air are invariably trapped; thus, assuming that the fabric to be impregnated is soaked in the first place in a solution of the resin in some volatile solvent, we would have a material containing about 15 to 20 per cent. of its volume of air which must be eliminated in the final product. Apart from the air, of course, there is the question of the solvent to consider.

It has already been pointed out how these bubbles are to be expected, particularly when the heat is applied from the outside, owing to the formation of an impervious external layer trapping condensation products, solvent vapour, and air contained in the base material. The presence of these bubbles, therefore, in the peripheral layers of the fabric-based laminates would appear to be a foregone conclusion, due to the very much higher percentage of air in the material, as compared to the paper base.

The effect of using a fabric base is more clearly shown by an examination of the core. If we take a longitudinal section of this material, such as that indicated by the line AA in Fig. 18, passing through one of the larger resin masses of the core, we obtain the result shown in Fig. 22. This illustration is a photomicrograph of a transparent longitudinal section of the fabric-base laminate taken in the direction previously indicated. The paper of the core can easily be distinguished and the presence of very large numbers of bubbles in the large resin mass in the centre clearly shows the result of

Fig. 24.—Longitudinal section of fabric laminate. Mag. 47 diameters.

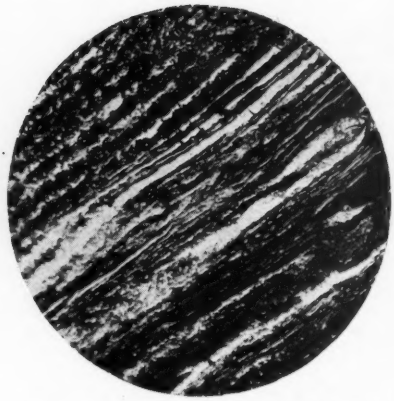


Fig. 25.—Longitudinal section of paper laminate. Mag. 47 diameters.

using fabric as a base. It will be noticed that even the smaller resin masses on either side of the main mass contain a high proportion of bubbles. The proportion of the volume of the main resin mass occupied by the bubbles is estimated, in this case, at about 20 per cent. It should be stated here that this condition resulted in spite of all possible care being taken to produce a perfectly cured product; a comparison with Fig. 23 shows a similar longitudinal section of the paper-based material, cured under the same conditions. In this case, it will be seen that there are very few bubbles indeed, the material is nearly perfect (the transverse lines in the resin masses are cracks caused in the sectioning), the only point calling for improvement being the reduction of spaces by increased pressure.

To obtain a direct comparison of the difference between the structure of the fabric laminate and the paper material, let us examine these longitudinal sections at a slightly lower magnification. Fig. 24 shows the fabric material at 47 diameters. A portion of the paper core is shown, the photograph revealing large interstitial resin masses, amounting to about 50 per cent. of the volume of the whole. One argument which could be advanced in favour of this structure would be that in being less regular than that of the paper it tends towards greater homogeneity.

If we define homogeneity in this case as being a perfectly even intimate mixture of the base and the resin, devoid of any regularity of structure, then this is true; but as against this we can say that whereas the structure is less evident, the mixture, as it were, is anything but intimate, and furthermore, when it is realized that the resin by no means impregnates the yarn to the extent of enshrouding each cotton filament, it will be seen that a third component exists in this mixture to an appreciable extent in the form of air in the weft and warp threads. Therefore, it appears from these conclusions that the ideal condition would be to have no inter-lamellar or (in the case of fabic bases) interstitial resin masses, but rather to have the base material perfectly impregnated, so that the finished product consists of layers of the base material whose surfaces are in intimate contact with the resin forming a continuous matrix building the whole together. Thus, Fig. 25, with a longitudinal section of the paper-base material at 47 diameters, shows how much nearer to the ideal is the paper base than the linen, although in paper we still have a material which it is impossible to impregnate completely.

(To be continued)

Pre-heating by High-frequency Currents

By A. J. MADDOCK, M.Sc., F.Inst.P., A.M.I.E.E.*

SUFFICIENT preliminary work has now been carried out to show that dielectric heating provides a powerful process for numerous branches of industry and confers properties not obtainable by any other known method of heating. Many advanatges arise from its use in the plastics industry for pre-heating moulding materials, and different manufacturers are likely to place these advantages in differing order of merit according to the particular moulding processes involved in their products. It must me emphasized, however, that H.F. heating is not a universal sine qua non and there are many instances where its use would definitely be of no advantage.

Pre-heating by high-frequency currents produces material, prior to moulding, which is:—

(a) Uniformly heated throughout its volume.

(b) Already plastic and near to the "curing" temperature.

Resulting from these properties the following advantages of this type of heating may be listed:—

(1) Increase in the thickness, hence volume and weight, of final product which can be moulded.

(2) Uniform and controllable conditions giving a product fully "cured" throughout, even in thick sections.

(3) Reduced "curing" time—to one-third or one-quarter of normal times—leading to a reduction of overall time-cycle where the "curing" time represents the major part of the cycle.

(4) Easy flow around inserts. This makes possible the use of reduced pressures—often to half that normally used.

(5) Reduced shrinkage of final moulding. Permits closer tolerances to be obtained and allows inserts, screwed directly into a moulding to be easily withdrawn.

(6) The moulded products are consistently uniform.

(7) Increased mechanical strength of moulded product.

(8) Reduced wear on moulds.

On the equipment side, the products of reputable firms have now taken on a form suited to the needs of industry, enabling them to be operated by unskilled personnel and yet capable of dealing with a multiplicity of jobs. In the author's opinion the electrode system, within which the heating takes place, should be designed by the manufacturer of the generating equipment in order to obtain the fullest advantages and most efficient operation; whether the electrodes are an integral part of the generator unit or are located separately is a matter to be determined for each broad class of work. Generally, for preheating thermosetting resins in pellet or powder state the complete equipment can form one unit, and it is with this class of work that these notes are concerned.

Equipment Design

Examples of two types of equipment are shown in Figs. 1 and 2, the former having an output power of 2½ kw., capable of heating up to 5 lb. of material, and the latter an output of 1 kw. suitable for loads up to 2 lb. in weight. As it is important for each load to attain the same temperature, the pre-heating is carried out on a constant-power and constant-time basis. Once set up for a given job, therefore, the operator has only to press a button at the commencement of

* Standard Telephones and Cables, Ltd.

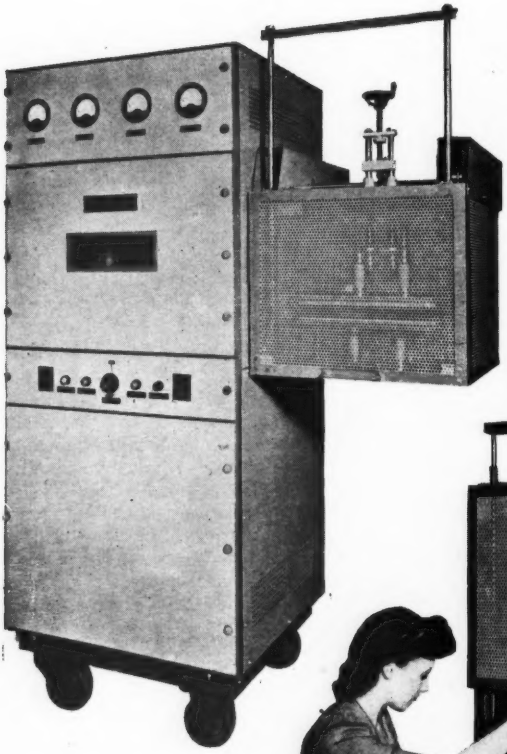


Fig. 1 (left).—2½ KW dielectric heating equipment. Electrode system particularly adapted for the plastics industry. Will heat up to 5 lb. of material.

Fig. 2 (below).—1 KW dielectric heating equipment. Convenient size for operator to be seated and serve several presses. Can be fitted with legs to raise height for operator to work standing. Will heat up to 2 lb. of material.

each heating operation and the power is automatically switched off at the appropriate time. This not only leads to accurate and repeatable results, but makes the operation as simple as possible. In nearly all cases unskilled personnel will operate the equipment so that preliminary adjusting devices such as voltage control, time setting, etc., should be inside the equipment and not accessible to the operator.

With the electrode system supplied as part of the unit, very complete

Fig. 3.—Close-up view of fully automatic electrode system and cage. Note ready access and free working space.

screening can be effected. Not only does this provide the necessary safeguard for the operators, but also ensures that the interference caused by radiation of electromagnetic waves is reduced to a minimum. Provision of a filter in the mains-input leads prevents similar occurrence due to R.F. energy fed into the mains supply.

As a multiplicity of shapes and weights of load has to be dealt with, it is an advantage for the electrode system supplied to be adjustable both in separation and area of the plates. Once set for a job, the electrodes may remain fixed in position, in which case the work is loaded in on trays. On the other hand, it may be more convenient for the operator to load the work directly on to the lower electrode, in which case adequate room for handling the work between the plates is necessary; this can be provided by making the top electrode automatically move away from the lower as the door of the electrode cage is opened.* The electrode system shown in Figs. 1 and 2 is of the latter type; adjustment for loads up to 3 ins. thick is possible by means of the hand-wheel on the top of the cage, in addition to which the top electrode rises 3 ins. when the door is opened. A close-up of the system with the cage door open is given in Fig. 3 which illustrates the ready access and free working space obtained.

The electrodes should be of robust construction and be so finished that the plastic material does not stick to them.

Composition of Load and Methods of Loading

The simplest load to handle is that made up of compressed preforms. The latter can either be loaded individually on to the lower electrode by the operator, as in Fig. 3, or on a metal tray, sliding in rails, which itself forms the bottom electrode. A quantity of pellets can be heated at the same time, but it is important to remember that, for a given set-up of the equipment, i.e., voltage and time cycle, each part of the load must have the same thickness, otherwise the thinner parts will not heat up so rapidly; this can

* Patent application No. 15814/44.

be appreciated after a study of Section 4 following.

Multi-impression moulds can be catered for by using a tray of the type shown in Fig. 4, which is actually one for 25 impressions. The tray resembles the wooden loading trays commonly used in moulding shops, but is made of metal and forms both the lower electrode for the H.F. heating equipment, and also the loading device for the moulds. When the pellets are hot the whole tray is removed from the H.F. equipment, placed over the moulds and the top sheet slid along, allowing the pellets to fall into the impressions. The top metal sheet, which holds the preforms in place, must occupy only a small fraction of the height of the pellets, and the holes in it must be of generous size, otherwise electrical shielding of the bottom, outer ring of the preform occurs, with the result that these parts attain a lower temperature than the remainder of the material.

When heating a number of preforms, and particularly as in such a tray-load as described above, it is very advisable, and almost essential, to have an air-gap between the top electrode and the top of the preforms. It would be impossible for the top electrode to touch all pellets equally, and thus uneven heating would occur, but with an air-gap it is possible to equalize the voltage-gradient existing across the pellets to a more uniform degree, and hence for all pellets to attain the same temperature. The air-gap also permits the use of sliding trays with fixed top electrode, allows the material to expand, permits the vapour to escape more readily and prevents flashovers occurring down the pellets due to accumulation of moisture.

When heating powder the air-gap confers similar advantages and, in fact, the author recommends an air-gap in nearly all cases. It is sometimes stated that this causes a waste of power, but this is erroneous. Output power is not wasted, for the air in the gap is not heated, but R.F. output voltage is wasted since a proportion of the voltage is dropped across the air-gap leaving a smaller voltage actually across the material being heated. This means a small increase in time required to attain a given temperature, but with a well-designed equipment with adequate output, this voltage is of small import. The addition of an air-gap is equivalent to adding an extra thickness to the material equal to the air-gap multiplied by the dielectric constant of the material.

It is quite feasible to pre-heat powdered resins up to a stage when the whole load coagulates into a plastic mass, so that it is unnecessary to make up compressed preforms; this is particularly useful where large blocks are concerned. If the temperature is not too high the blocks can

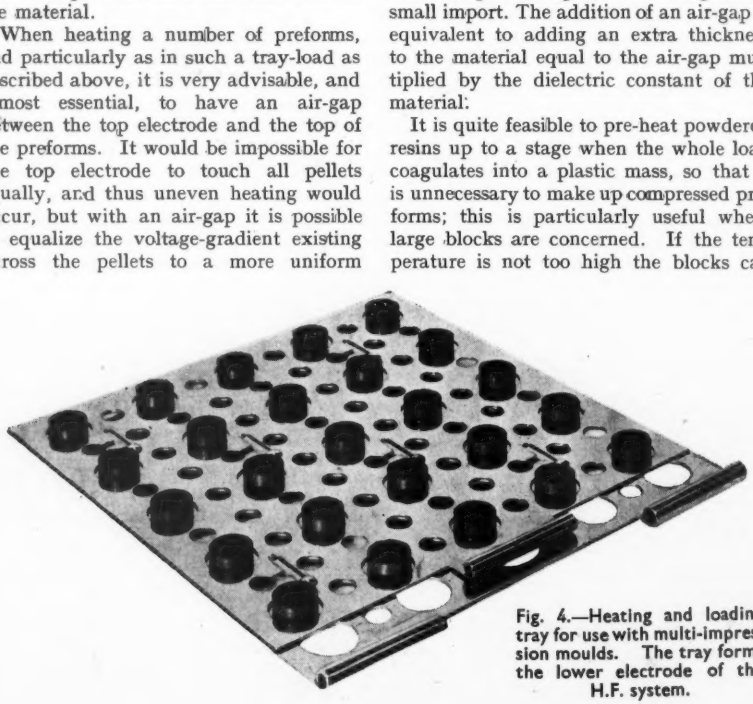


Fig. 4.—Heating and loading tray for use with multi-impression moulds. The tray forms the lower electrode of the H.F. system.

be broken up by hand, if desired, for insertion in the moulds. On the other hand, if the powder must remain in a granular form so that it may be poured into deep cavities, then the heating must be discontinued at a lower temperature, before coagulation sets in; e.g., for material having wood-flour filler this occurs at about 70 degrees C.

One of the difficulties of heating powder is in finding a suitable container which will not itself become excessively hot in the H.F. field. This is a line in which more work must be done as the final answer has certainly not been reached. At present containers of wood, cardboad, paper, glass, " mycalex," and mica-filled resins are used, but all have some disadvantage, either in heating-up or in absorbing moisture. It is to be hoped that the plastics industry will soon produce a material which does not soften or deteriorate until well above 150 degrees C., and which has a loss factor not exceeding 0.008 (e.g., a power-factor not greater than 0.002 and a dielectric constant of about 4). Such a material would be suitable for containers and would also have many other applications in the radio industry, for which the only low-loss plastic materials available at present soften at too low a temperature. Of woods, we have found hemlock to be the best, as it does not heat up very rapidly and, fortunately, is often readily procurable from good quality packing-cases! The white-coloured wood of straight grain and free from resin should be chosen. From the heating point of view balsa is even better, but is too fibrous and loose-grained to use; many other, harder and close-grained woods are unsuitable, due to their rapid rate of heating. Several trays should be used in rotation to allow a period of cooling for each.

The temperature to which the material should be heated is a matter best determined by actual tests taken in conjunction with the moulding process. The temperature will be around 120-130 degrees C., and curves already published for a 1-in. thick block of general-purpose material* show that in going from 120 to 130 degrees C. a reduction in curing time of 2.4 to 1.3 mins. is obtained, but that from 130 to 140 degrees C. the gain is only from 1.3 to 1.0 mins., and beyond this temperature pre-curing sets in rapidly.

Transfer of material, after pre-heating, from the electrodes to the mould should be carried out as quickly as possible, and a general time to aim for is of the order of 15 secs., but longer times can be tolerated, especially if the temperature of pre-heating is reduced a few degrees. It will be appreciated from these remarks that the dielectric heating equipment should be reasonably near to the press.

The outer layers of pellets pre-heated by dielectric heating are actually at a lower temperature than the interior, due

* G. Dring, " Plastics," 1944.

Fig. 5.—Sections cut from lavatory seats moulded by normal method and with H.F. pre-heating. Total weight of complete article 4 lb. (Left) Normal method, 12 mins. cure; high percentage of rejects due to blistering. Density 1.26 gms/c.c. (cavities filled with chalk for clarity). (Right) With H.F. pre-heating, 6 mins. cure; solid core, fully cured, no blistering. Density 1.38 gms/c.c. (Mouldings by Stadium Ltd.).

to the cooling taking place to the air and to the electrodes. In general we consider this to be an advantage rather than a disadvantage, for it is these parts of the pellets which come into contact with the hot mould and so become heated first. Thus by the time the material is being forced into the mould the whole of the volume, including the outer layers, is at a reasonably uniform temperature.

Because moisture is driven off in the pre-heating process and because the moulded product is uniformly cured and without a porous interior (compare the densities of the mouldings in Fig. 5), a greater weight of powder must be allowed per article, the increase being of the order of 1-2 per cent. On the other hand, the weight allowed without pre-heating may have been on the generous side, the excess passing into the flash, but as the flow is now so much easier and rapid a reduction in weight may be possible. These are questions that can only be settled by consideration of individual jobs, but the matter is mentioned here since either case may arise.

Power Requirements and Times of Heating

On theoretical grounds it is easy to calculate the energy required to heat any mass of material through a given temperature rise when heat loss from the outer layers of the material is neglected.* Thus to heat any material having a specific heat of 0.35 cals/gm/degree C. (an average value for a phenolic resin with filler) through a temperature rise of 100 degrees C. (i.e., for a final temperature of about 120 degrees C.) requires a supply of energy to it of 40 watt-hours per kg., or 18 watt-hours per lb. weight.

The power required, i.e., the rate at which energy is to be supplied, will depend, of course, on the time in which the temperature rise occurs; the product of power and time is equal to the energy. Thus, for the above material, if the time is to be 1 min., the power will be 2.5 kw. per kg. or 1.1 kw. per lb. For double the time, the power will be halved, etc.

* For simple data charts enabling calculations to be made rapidly see: A. J. Maddock, "Electronic Engineering," 17,635, 1945 (August).

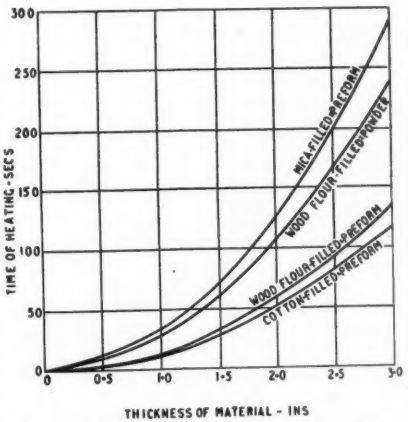


Fig. 6.—Variation of heating time with thickness for different types of phenolic thermosetting materials.

Whether an equipment can deliver energy at such a rate into a particular load is not determined by its total capacity rating in kilowatts, but by the voltage-gradient existing across the material being heated.

The output voltage of a high-frequency generating equipment depends to some extent on the load placed between the electrodes, but it is obvious that it will have an upper limit for each equipment. It follows then that the time of heating will increase as the thickness of the load increases, for a fixed output voltage. Furthermore, the time is proportional to the square of the material thickness, if other factors remain constant, so that the power input to the material also falls off at the same rate. The time of heating does not depend on the area of the load but only on its thickness.

To illustrate these points, and to indicate the order of magnitude of the times, Fig. 6 is appended; the curves are all shown for an approximately fixed output voltage and a final temperature of 130 degrees C., i.e., a rise of 110 degrees C. The increase of time with the square of the thickness is apparent, and the curves illustrate also the difference in heating time between various grades of thermosetting resins.

As is to be expected, the mica-filled material heats at the slowest rate due to its low loss-factor, whilst a composition containing such a material as cotton, having a poorer loss-factor, heats most rapidly. The times are dependent, also, on the amount of moisture in the material; the greater the moisture content, the more rapid the heating. This is one of the advantages of high-frequency preheating, as it helps to produce heated preforms of a more uniform moisture content, thus counteracting, to a considerable extent, the day-to-day variations which occur with atmospheric humidity. It will be noted that a material in powder form takes about twice as long to attain a given temperature as its counterpart in pelleted form. This is due to the large amount of air around the granules causing the voltage-gradient across the actual resin to be less than in the case of pellets.

PLASTIC MOULDINGS AND ZINC ALLOY DIE CASTINGS

THE Zinc Alloy Die Casters' Association has published a most informative leaflet under the above title. It makes a most interesting comparison between plastic mouldings and zinc-alloy die castings, description, manufacture, and properties.

Moreover, there is a valuable chapter describing the combinations of the two materials which result under the conditions chosen, in important improvements in the value of the final product. We select the following notes from this portion of the booklet:—

Combination Plastic Mouldings and Zinc Alloy Die Castings

Zinc alloy die castings are employed in conjunction with moulded plastics, both as relatively small inserts and as castings representing a large proportion of the composite product. As metal inserts they are used to provide additional strength, to facilitate assembly, or to serve as electrical conductors.

There are many advantages in favour of die-cast zinc alloy inserts. Die casting represents the most rapid and, in many cases, the most economical form of production of metal components; the more complicated the component, the greater being the economy in production in comparison with other methods.

Zinc alloy die castings, which may include accurately cored holes and screw threads, require little or no subsequent machining. They may range in weight from over 30 lb. to a small fraction of an ounce and provide a good bearing surface where necessary. Their coefficient of expansion is greater than that of steel or brass, and thus they are more suitable for use with moulded plastics. Their electrical conductivity is equal to that of brass.

They may be cast with knurled or milled surfaces, or with flanges to secure adhesion to the moulding, and it may be feasible, when several inserts are required, to die cast these on a skeleton framework. This should facilitate speedy location of the inserts in the mould and will have the added advantage of stiffening the plastic moulding.

When a plastic coating is moulded over a die casting, the combination is one of adequate rigidity and strength coupled with the decorative value of the plastic. At present this development appears to be confined mainly to more solid articles, such as door furniture; but there would seem to be wider fields of application on account of the thin wall section possible with zinc alloy die castings.

Conclusions

Although sometimes it is possible to use either plastic mouldings or zinc alloy die castings for a particular component and thus opinion may be divided, it would appear that the known facts justify the following general conclusions on the applications of the two materials.

Plastic mouldings are likely to have little effect on engineering applications of die castings where high mechanical properties and dimensional stability are required. In such cases zinc alloy die castings will hold their own. For ornamental uses, however, they are likely to meet serious and increasing competition from plastic mouldings.

As regards the use of the two materials in combination, the future appears to hold out many new and interesting possibilities in which full advantage will be taken of particular merits such as the strength of the metal and the decorative appearance of the plastics. We need scarcely add that the methods of utilising zinc die castings are already known to the industry. We hope that this booklet will still further promote their use.

INCREASING OUTPUT CAPACITY OF MOULDING PLANT

Presenting a brief discussion on the rational organization of plant and operating conditions for achieving maximum output in plant for thermo-setting mouldings. (After Achilles and Römer, "Kunststoffe," 1943/33/2.) It might be pointed out that there has recently come to light a lay-out of a French works in which, by an ingenious system of colouring, the effective operating period for each machine per shift is clearly indicated, thus facilitating adequate emergency distribution of work during rush periods or conversely closing down of redundant presses when less work is available.

THE capacity of plastic-moulding plant can frequently be increased without installing new machines and equipment, merely by maintaining optimum operating conditions with reference to preheating, temperature, pressure, curing time, etc. The following data are taken from an article by O. Achilles and E. Römer,[1] in which records were kept for the production of a similar moulding in 12 different moulding machines.

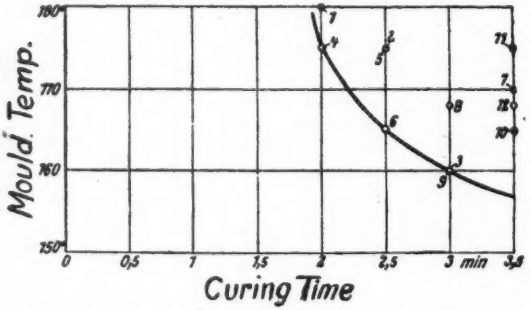


Fig. 1.—Relationship between moulding temperature and curing time for the twelve presses enumerated in Table 1 (q.v.).

Correct Organization

In plants with numerous presses of varying size and type, a suitable planning organization must see to it that each press is used to the best advantage. For instance, the size of the press (which determines the absolute pressure exerted) has to be adapted to the size of the moulding. The shop manager should have a table or a card index, which gives him accurate information about the utilization of each press. Only then is he able to ascertain the best means of using it and be in a position to give accurate dates of delivery, etc.

Furthermore, close contact is desirable between moulding shop and the drawing office, where the moulds are developed. First, the draughtsman will utilize the experiences of the moulding shop; secondly, he will consider in his designs the dimensions of available presses.

Preparation of the Moulding Mass

In order to achieve optimum results, single operations in the moulding shop have to be studied from the point of view of economic engineering. It is already possible to ensure accurate filling of the moulds, and should no longer be necessary to allow the press operator to scoop out the moulding powder from the barrel by guess, thus causing considerable waste. Even in the case of scoops, the size of which is adjusted to the size of the mould cavity, much powder is wasted, as the

Table 1.—Comparison of Capacity of 12 Moulding Plants of Different Sizes. Data for the Production on each Machine of the

Table 1.—Comparison of Capacity of 12 Moulding Plants of Different Sizes. Data for the Production on each Machine of the Same Phenolic Resin Moulding with Woodflour Filler (net weight about 100 gms.).

1.—Moulding plant	1	2	3	4	5	6	7	8	9	10	11	12
2.—Moulding pressure, tons per component	30	17	25	20	25	25	20	20	25	16.5	20	15
3.—Moulding temperature, °C..	180	175	160	175	175	165	170	168	160	165	175	168
4.—Preformed diameter, mm.	40	—	42	54	46	42.5	51	52	50	55	48	—
5.—Difference between filling weight and net weight in gms.	3.0	2.0	3.0	4.0	10.0	6.0	9.0	4.5	11.0	0.5	9.0	4.0
6.—Rejects during burring, per cent. ..	1.5	3.0	2.5	2.0	3.8	1.0	4.0	1.5	3.0	5.0	2.0	7.0
7.—Moulding rejects, per cent.	0.5	1.0	1.0	1.0	2.0	?	0.5	1.0	1.0	1.0	?	1.0
8.—Curing time in mins.	2.0	2.5	3.0	2.0	2.5	2.5	3.5	3.0	3.0	3.5	3.5	3.5
9.—Sequence time	2.3	3.2	3.8	3.8	3.8	3.8	5.0	5.0	5.0	5.0	5.0	6.1
10.—Output per charge in components ..	3,750	2,700	2,250	2,250	2,250	2,250	1,720	1,720	1,720	1,720	1,720	1,415
11.—Possible increase in capacity, referred to capacity of No. 1 plant, per cent. ..	—	39	63	63	63	63	118	118	118	118	118	165

weight of the taken mass depends on many chances, for instance, on its looseness. In order to avoid those and other disadvantages, larger moulding plants almost exclusively favour preforms (tablets or briquettes). Progress made in tabletting during the past few years includes the preforming of powders containing chipped filler materials; this is, of course, only possible for tablets of limited size.

Practical Investigation

In order to obtain data on the possibilities of increasing capacity, the weekly productivity of 12 moulding plants of different sizes was determined for a given workpiece. The various service data are compiled in Table 1. Row 5 contains results on the surplus weight., i.e., the difference between the weight to be filled into the mould and the net weight of the component. Differences between 0.5 to 11 g. (1-30 to $\frac{1}{3}$ oz.) were observed, which cannot be solely traced to wear of the mould, as it is usual for the component to have an overweight of about 2 to 3 per cent. With more careful supervision in the plants investigated, considerable quantities of moulding powder could have been saved.

Preheating of the powder can also contribute to the increase in capacity, as, with suitable preheating, curing time can be reduced correspondingly. With equal auxiliary times moulding plant 7 could have yielded, for instance, an output increase of 25 per cent., if the heating time had been reduced from 3.5 to 2.5 mins. In the method of preheating moulding powders itself, great progress can still be expected.

Moulding Technique

The capacity of a press depends ultimately on the time taken for producing a moulding, and this can be subdivided into curing time and supplementary time. Table 1 reveals great variations in supplementary times between the various equipments investigated (difference between rows 8 and 9). Whereas in plant 1, removal of work from the mould and cleaning of the mould and refilling

need only 0.3 min., this time becomes 2 mins. in plants 8 and 9, and 2.6 mins. in plant 12. These data clearly show that, through processes better adapted to the purpose, quicker operation can be achieved, resulting in higher productivity. Even assuming a not very efficient press and a worn mould, it cannot be understood why, for a given operation, one plant functions at one-ninth the rate of another.

This can, of course, possibly be explained by the fact that in the plants with long supplementary times, one operator has to serve several presses and that individual presses are thus standing idle for some time. The comparison shows clearly that, in these plants, economy is attempted at the wrong end. The plant manager should see that the presses are, if possible, always under pressure. When using multiple moulds it may even be useful to let two operators service one press, in order to reduce supplementary times to a minimum with reference to curing time.

Curing time is mainly determined by pressure and moulding temperature, the same moulding powder and the same component being assumed. With high specific pressure, the mass flows quicker into the mould cavities than with a lower pressure. Row 2 (Table 1) shows that the pressure varies between 15 and 30 tons, whilst, in general, with decreasing pressure, weekly capacity is reduced. The correct order of pressure is, therefore, of some influence on the capacity of a press; by correct planning it can be arranged that a press with most suitable pressure becomes available for each particular component. It is, of course, evident that excessive pressures are also to be avoided, as they may, to no useful purpose, cause extensive wear of the moulds.

Moulding temperature depends on the moulding powder, but bears also a relationship to the shape of the component. The "taller" the component, the lower the mould temperature has to be kept, to prevent the curing of the mass before it has filled the cavity or has flowed through the mould. With electrical heating, any desired temperature can be adjusted; however, suitable arrangement of the heating elements and bands has to be observed to exclude local overheating. Automatic temperature control is of advantage. With steam heating, mould temperature depends on boiler temperature; in the mould a temperature up to 165—170 degrees C. (330 to 340 degrees F.) is usually obtained.

When treating phenol resins, temperature differences of ±5 degrees C. are usually without importance; due to this, the maintaining of correct moulding temperature as a means for increasing capacity is usually quite ignored. If, in Table 1, one compares moulding temperature with the curing time, there seems at first to be no connection (Fig. 1). The reason for this is that, in many cases, curing time is longer than is really necessary for the hardening of the mass, otherwise the fact that for the same temperature of 175 degrees C. (348 degrees F.) plant 4 needs only 2 mins. and plant 11 about 3.5 mins. for curing cannot be explained, the same moulding powder is assumed in both cases. If one uses, however, tests showing only minimum curing times, i.e., those lying at the left, a curve can be plotted giving the inter-relationship between mould temperature and necessary minimum curing times. In all instances, to the right of this curve, components are hardened for a longer period than required. Should the curing time in the cases connected by the curve be selected at too low a level, the numbers of rejects in these plants would obviously increase. Therefore, one can see directly from the diagram where increase in capacity can be obtained by using the optimum curing time. The influence of curing temperature is only of a secondary nature.

The amount of rejects in the 12 plants investigated varies between 1 and 7 per cent. Through correct filling and suitable working conditions, correct cleaning of the opened mould, still further savings can be obtained. In deburring the moulding, reject rate is generally about 1 per cent., a value which can be considered as low.

How Should the Control be Carried Out?

The bottom row of Table 1 shows the increase in capacity to be achieved in order to reach the output of plant 1. As it cannot be assumed that the presses in plants 2 to 12 operate less satisfactorily than those in plant 1, one can say that the capacity of plant 1 *could* be achieved by the other plants if only more suitable working conditions were created. It is, of course, not proved that plant 1 already runs at optimum capacity, as only comparative data were looked for, and no attempt was made to achieve most favourable working conditions in the reference machine.

In order to achieve optimum conditions, factors for most suitable production for a single component have to be determined, and times, temperatures and pressures found in the investigation have to be carefully maintained; it is useless to rely on values given by general experience.

The standard weight of the moulding should be determined by examining a range of examples. For high outputs, sub-contracted to different plants, it would seem useful for the customer to ask one contractor to fix a plan for optimum production, which is then applied by the other sub-contractors. In this way, best output is achieved with the smallest loss in time.

Numerous instruments have been developed for controlling pressure and temperature; for electrically heated moulds thermostats are applied which cut the current off after a distinct temperature is reached. The simplest way for controlling curing and supplementary times is to use recording instruments which trace the stroke of the ram in relation to the time elapsed (for instance, the Peiseler-Diagnostiker). From such records the following data can be obtained:—Supplementary times during which the press is open; curing time during which the press is closed; number and duration of withdrawals; number of the parts produced, including rejects; number and duration of service pauses. The use of such instruments prevents operators attempting to balance pauses by moulding parts too quickly, i.e., by not allowing sufficient curing time. [Modern presses are frequently worked according to an automatic time cycle, so that control by recorders, as outlined above, seems hardly necessary.—ED.]

Comparison of Costs

Production costs are based on material used, wages, number of rejects and overheads. Costs reflect efficiency, hence their calculation per unit is, even in the small moulding plants, of importance.

British Standards for Building Materials and Components

When Handbook No. 3—British Standards for Building Materials and Components—was issued last December, it was explained that there were still many specifications relating to building which were in course of preparation and that when work on these was completed, the relevant details would be issued in a supplement to the Handbook. Many of the additional standards having been published the supplement has now been prepared and issued. It includes the summarized technical requirements of 82 standards.

Eighteen of these are revisions of standards included in Handbook No. 3 and the information about them accordingly supersedes that given in the Handbook. The new standards cover a wide field and include plasters and plaster board; sanitary appliances (sinks, washtubs, w.c. pans and plastic seats); lintels, sills and copings (in clayware, concrete and natural stone); domestic appliances (gas and solid fuel); wallpaper; kitchen cupboards; colours for distempers; draining boards; steel fabric, etc.

An up-to-date subject index covering the two volumes has been included and clearly indicates whether the specification required is to be found in the supplement or in the original issue of the handbook.

Copies of the supplement, price 7s. 6d., are available from the offices of the British Standards Institution, 28, Victoria Street, Westminster, S.W.1.

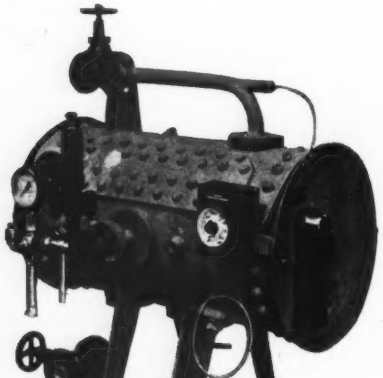
Copies of the original Handbook are still available (price 12s. 6d.) and the two volumes which together give details of 228 standards can be obtained for £1 post free.

PRODUCTION NEWS

Raw Materials, New Plant, Works Organization, Control Apparatus, Research, Personal and Trade Notes

SUPERHEATING BY ELECTRICITY.—Considerable advance is being made in Great Britain and other countries with the use of the small electric steam and hot-water boiler, which, for installations up to, say, 1,000-1,200 kw., representing a wide field of application, is no more costly to operate than the use of coal or other fuel when the price of electricity is any reasonable figure, such as 0.30-0.60d. per unit.

Arising from this, much interest attaches to the use under certain conditions of electricity for superheating, and well-known specialists on the subject are Bastian and Allen, Ltd., of London (11, Bedford Square,



W.C.1) who make electrode steam and hot-water boilers as well as electric resistance boilers, heat storage systems, air heaters, and domestic and industrial water-heaters, as well as superheaters.

A typical installation they have supplied in the latter connection for a large engineering research laboratory is an electric superheater rated at 16 kw. for 346-volt 3-phase 50-cycle, which supplies superheated steam at 200 lb. per sq. in. to a temperature of 500 degrees F., the maximum capacity being 450 lb. of steam per hour.

In general, the principle consists in the use of a horizontal steel cylinder containing a series of 18 horizontal electric resistance heating coils, each of which is contained in a small-diameter steel tube fixed horizontally throughout the length of the casing in five rows, one above the other, connecting to a terminal cover at one end of the casing. The steam enters the latter and is superheated by contact with highly heated steel tubes containing the resistance coils inside sealed off from the steam, the whole arrangement also being equipped with thermostatic control gear, so that the temperature of the steam is maintained automatically at 500 degrees F., or any other figure.

Superheating in this way for smaller installations has all the pronounced advantages of electric heating in general. These include no labour, a very high thermal efficiency, relatively small size and weight per unit output, extreme flexibility in the sense of starting up or shutting down in a very few minutes, safety, and very easy and accurate automatic regulation of the temperature of superheat. It is, of course, an easy matter to work out the operating costs, taking the thermal efficiency as 95 per cent., whilst the whole of the inherent troubles with the use of gaseous, liquid, or solid fuels are cut out; that is, dust, grit, smell, smoke, poisonous fumes, and gases, and the necessity of a chimney, together with a large amount of storage space for the fuel, and complications as regards the disposal of dust, ash, and clinker.

DRAINING BOARDS.—British Standard 1226: 1945 has been published by the B.S.I. at 2s. net, post free. The standard has been approved by the Ironmongery and Sanitary Fittings Industry Committee, which included a representative of the British Plastics Federation. The types of draining boards include those made of plastics, the types of resin and apposite British Standards being indicated.

It is interesting to note that a British Standard for aminoplastics is in preparation.

AERO RESEARCH TECHNICAL NOTES.—Aero Research, Ltd., has now issued Bulletin No. 33, of this excellent practical series. It deals with the making

of plywood with Aerodux 14, a reddish, powdered phenolic resin, readily dispersed in water or alcohol.

BAKELITE, LTD.—At the annual general meeting held on June 28, Mr. H. V. Potter, Managing Director, gave a brief report of the company's activities and "adventures" during the war period. (We refer to the enemy bombing of Tyseley as "adventures," in which the company's employees emerged with flying colours.) In his speech, Mr. Potter referred to the early work of Sir James Swinburne on synthetic resins which was contemporaneous with Baekeland's work—a fact which most historians are prone to omit in their stories. He also alluded to the company's manufacture of vinyl plastics, which will be continued and expanded.

ASSOCIATED WEAVERS.—In his statement accompanying the report of this company, the chairman stated that by the purchase of all the shares of a company manufacturing leather cloth, plastic cloths and rubber cloths, most of the upholstery fabric requirements of the furniture and motor trades can be supplied.

DR. G. E. HAEFELY has severed his connection with Micanite and Insulators, Ltd., and intends establishing himself as a consultant in plastics.

SOCIETY NEWS, ETC.

The annual general meeting of the Southern Section of the Institute of the Plastics Industry will be held at the University College, 6.30 p.m. on Wednesday, September 19. This will be followed by a film show.

Examination Results

The City and Guilds Institute Plastics first year: 16 members of the Plastics Courses run by the Southern Section passed the examination, which included two First Class Passes.

CENTRELESS GRINDING

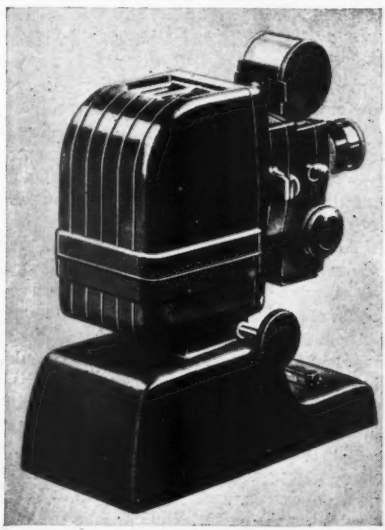
Arthur Scrivener, Ltd., of Tyburn Road, Birmingham, have just issued a comprehensive work on the above subject which deserves much more than passing comment. This book, if it has not been compiled by one of the experts now advocating the issue of intelligent catalogues to improve our export market, can certainly teach them how it should be done.

It is of course not a catalogue. But it does describe the machines of this company in such a new way that will make an impression on all buyers in this company and abroad.

It is divided into three sections. The first discusses the principles involved in centreless grinding and the broad classes for which the process is suitable. The second deals with the design of centreless machines. The third, which is the most interesting, gives hundreds of examples of actual work ground on such machines. Each page comprises two; each is headed with an excellent photograph of the job, while immediately below it is a drawing of the part positioned between the wheels. Below this are given details regarding the past and operational and production figures.

NEW PLASTIC PROJECTOR

The new Gaumont British Film Strip Projector is the latest example of the styling of Mr. Richard Lonsdale-Hands, the British industrial designer. Its clean lines are an example of how a professional industrial design organization can introduce into a utilitarian product a dramatic and appealing shape that gets the best out of the process of manufacture. The top lamphouse casing and controls are in moulded plastics and the base is an aluminium casting.



Planned Mould Maintenance Service Aids Economical Production

Section XV

By W. M. HALLIDAY

Continuing the study of Inserts, Insert locating, holding and feeding mechanisms, from Section XIV published in the July issue of "Plastics," which mechanisms have been found capable of easy, safe and inexpensive introduction into Injection Mould Constructions.

Further consideration is now given in this present section to a number of simple mechanical devices and methods whereby hand feeding of insert components may be greatly facilitated, coupled with lessened risk of developing faults, interrupted production, or damage to moulds.

Several very interesting kinds of feeding and retaining arrangements will be illustrated, these being specially adapted for readily introducing tubular or cylindrical inserts into more or less inaccessible locations. In connection with these, preferred forms of design and construction will be particularly noted in order to avoid a number of undesirable features whose presence leads to increased maintenance attention being required, as well as less efficient production and operation of moulds.

IN the preceding section of this series, see July issue of "Plastics," the author devoted considerable attention to the general question of insert usage, with especial emphasis upon the most desirable forms, shape and arrangement such parts should possess in order to ensure efficient moulding operations; satisfactory anchorage of the insert into the moulded article.

Alongside this, consideration was also given to the preferable forms of devices or adaptations to mould constructions so as to secure accurate, safe, and adequate location or retention of the insert piece prior to the commencement of the moulding cycle, during actual moulding, and throughout the ejection stages after the moulding has been formed.

The main purpose the author had in view throughout that discussion of the various design and constructional forms was to offer useful indications to the reader of the numerous and possible lines of troublesome mould operation connected thereto, and also to point out some of the many ways in which increased demands upon the skilled attentions of the maintenance toolmaker would be required.

Doubtless it will have been appreciated that often a very slight alteration or minor modification to the shape, size, or whole design of the insert component itself, or its supporting pin, sleeve, etc., can be made with beneficial results so far as eliminating the many risks of indifferent operation, faulty parts, and serious injury to mould members.

It is again strongly urged, however, that in all cases where inserts have to be employed in injection moulds the most careful attention and study should be bestowed upon each individual project, especially whilst it is still in the early design stages, so that the best form shall be selected, and the least complication of mould constructed effected. Only very rarely will it be possible to apply hard-and-fast rules governing these points.

On the other hand, it must be equally well appreciated that many instances do occur where it is not possible or convenient to contemplate any alteration to the shape or size of the insert piece to secure the above ends. For example, sometimes a mould cavity is of very great depth with the insert located on the bottom end with consequent difficulties in effectively locating same. Or the cavity may be severely restricted in diameter at the point where the insert resides. Again, if the insert has to be situated at an awkward angle relative to the mould parting-line it may be found that difficulties arise which are not capable of

solution merely by changing the shape or dimensions of the insert itself.

In order then to illustrate ways in which some of these troubles may be overcome or even entirely avoided, it is proposed now to describe a number of practical examples of injection moulds which may be taken as typical representations of such troubles, and whose solution may equally be regarded as typical of the manner in which the ingenious mould engineer may deal with the difficulties.

Locating Cylindrical Inserts from Ejector Rod, or other Sliding Member

The first of such commonly encountered problems to which the writer desires to direct attention relates to the practice of locating a cylindrical type of insert component within the hole, or a portion of same, in which an ejector rod or other similar sliding mould member, is normally located. This practice is more widespread in use than one would imagine from the many undesirable features associated with it.

By the way, it should be noted that generally it is possible to arrange a mould construction in such a manner that the insert is located either upon the plane of the parting-line surface, or at right angles to that plane. If this is done it invariably permits considerable simplifications being effected in the mould construction, and greatly assists towards easier and smoother working. Maybe because of this fact many designers are rather too apt to make use of any existing holes, recesses and the like, needed for housing other mould members such as cores, or sliding ejectors for the retention also of inserts.

Referring to Fig. 1, this illustrates clearly the several drawbacks inherent in locating the insert part within the ejector-rod guide hole. This view shows a sectioned partially assembled injection mould for producing a flanged hollow cup-like plastic component. It will be observed that the base wall of this is thickened up by means of an inside and outside boss, in which is securely anchored a parallel cylindrical stud. This latter insert piece is required to project a short distance both within and outside the base of the cup.

For the sake of clearness some important portions of the mould construction are not depicted, sufficient only being illustrated to demonstrate the several disadvantageous features associated with this method of locating the insert stud.

It will be noted that this insert stud is located laterally within the movable mould block at right angles to its parting-line. It is pocketed within the forward end of the ejector-rod guide hole, the rod itself being fore-shortened sufficiently to permit the requisite amount of insertion of the stud as shown.

With this construction, the endwise or longitudinal location of the insert stud is accomplished each time by bringing it

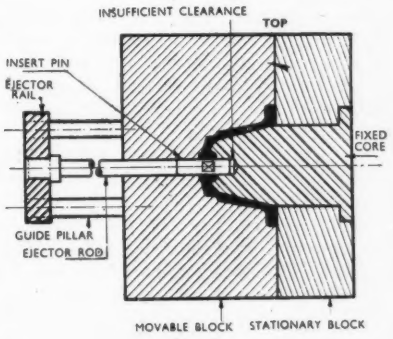


Fig. 1

into contact with the endface of the ejector rod when this latter member has been withdrawn into its extreme leftward position coincident with the injection of a fresh charge of plastic into the mould. The insert stud not only seats within the ejector rod guide hole in the movable block, but also at its other end resides within a suitable recess cut into the endface of the fixed core member situated in the stationary block.

Several important disadvantages both in respect of mould construction and use are connected with arrangements of this

kind, and will be well worth while carefully noting by both designers and maintenance toolmakers.

1. In the first place, concerning the endwise location of the insert stud, it will be apparent that any untoward alteration or slight variation in the position of the ejector rod itself within its guide hole must similarly alter the position of the insert stud, and the amount of its projection into mould cavity and the fixed core in other half of mould.

As is very well known amongst toolmakers and mould engineers, it is often exceedingly difficult to ensure absolute uniformity of ejector rail and rod location shot after shot, or over a large number of cycles. Numerous minor factors usually conspire to render such repeated exact positioning of the ejector rail or rod possible. Of course, where the ejector mechanism, etc., can be made of very robust construction and of such a substantial design as to be almost foolproof it will be possible to keep such variations in ejector rod location within very small limits. But in the general run of mould manufacture in which competitive price plays a major part, the cost of installing such a foolproof mechanism is often prohibitive.

2. A few causes of ejector-rail mislocation may usefully be listed for the guidance of toolmakers as follow:—

(a) Accumulated dirt, oil residues, or similar extraneous materials allowed to adhere to rods, guide pillars, etc., may cause the working of the rail to be stiffened, or restricted in its movement at one end of its stroke.

(b) Because of such undesirable accumulations the ejector rail may be caused to travel slightly askew on its guide pillars leading to some mispositioning of both rods and any insert pins housed within the rod guide holes.

(c) The guide pillars on which the ejector rail is arranged to slide may become bruised, roughened, bent, or loosened in respect of their fixture to movable mould block. Here, again, one or all of these causes may allow the rail to have undue slackness or to move non-squarely with mould block.

(d) Rail return springs may also fatigue or completely fail by breakage, thereby permitting the rail to swing askew on its pillars when being moved to and fro. This feature will lead to rapid wear on guide holes in rail, bending of the pillars, misalignment of rods, and inability to determine precise duplication of their endwise position with guide holes.

(e) The rail, rods or pillars may also suffer damage, resulting in distortion of these members and perhaps permanent injury damage to the mould. If the guide pillars become bent or the rods are badly distorted it will be found that the rail is extremely hard to move at one portion of its stroke, thereby tending to produce misplacement of the insert rod.

(f) Trouble may also sometimes ensue when the ejection of the finished moulding takes place, as in the following manner. Should an insert stud be too tight a fit within the rod guide hole, slender ejector rods bearing against it may be distorted or even fractured when ejecting the finished part, as they will then have the normal sticking of the shrinking plastic moulding plus the tightness of the insert stud to overcome. This may easily produce distorted or bruised rods, and there will also be a tendency to mushroom the contacting end of such slender rods due to the greater resistance set up by the tight-fitting insert. Removal of such a stud insert will eventually produce a roughening of the inside surface of the guide hole and may lead to a seizure and breakage of the rods when they move forward to pass over such damaged hole surfaces.

In actual practice this undesirable operating snag often occurs, and the maintenance toolmaker has continually to be on the look out for signs of such roughening of hole surfaces, tightening of the sliding action of the slender rods, and increasing tightness of fit between the insert stud and its housing hole due to the raising of bruises, etc.

(g) In the case where very long production runs are engaged upon it will often be found that deleterious wear is caused in the rod guide hole, especially at its inner end, converging into the cavity area due to the added contact of the insert parts to that of the normal sliding action of the ejector rods. This will produce undesirable results, such as creation of additional flash around the sides of the insert, and difficulties may be encountered in its removal from this latter member; there may also be admission of flash into the ejector rod guide hole, which, again, will interfere with the free sliding movement of this member. Furthermore, the development of such wear will in time cause the insert stud to be such a slack fit that it is very easily jarred out of its correct endwise position when the mould blocks are being closed.

(h) Another commonly occurring fault or source of mould operating worry lies in respect of the slack-fitting ejector rail and its rods. If the rail is a very easy fit on its pillars, due to wear, damage or other cause, such play may permit it to move slightly out of its correct position as the mould blocks are closed. The insert stud may then also become misplaced, which will then result in a faulty moulding or a trapping of the metallic insert when mould blocks are fully closed. Thus serious damage may be done to the moulds.

(i) Yet another fruitful cause of insert misplacement, faulty mouldings, and mould injury concerns the failure to provide adequate means for the escape of trapped air from the housing holes or recesses in which the insert member is situated. This is clearly illustrated in the sketch in Fig. 1. Here it should be noticed that the recess in the endface of the fixed core member in the stationary mould block is made far too short, so that any air trapped by the entry of the insert stud as moulds are closed cannot escape freely. This will be particularly important if the fit of the insert within the holes is maintained close. Trapping of air in this fashion will result in the insert being shifted slightly out of its proper position, or may lead to stiffened working of the mould at the point when blocks are nearly closed. Matching holes in which insert pins have to reside should be made of ample depth beyond that of length of insert. Trapped air may be not the only source of trouble arising from this lack of clearance. Thus excess plastic material, lubricant, dirt, etc., may all find residence within such holes, and interfere with the entry and position of the insert.

From this brief enumeration of some of the chief troubles and their causes to be expected from such arrangements being considered, it will be apparent that in those mould constructions where it is impracticable to avoid use of the ejector rod hole as the retainer for the insert, there should be close attention devoted to all questions concerning ejector rail design, guidance and operation. As will be appreciated, all such components of the mould should be very substantially proportioned, fully mechanically operated, free from the unreliable action of return springs, etc., so far as ever possible, and so aligned and guided as to obviate any tendency to skew, early wear likely to lead to twisting and slackness, and finally misalignment.

In servicing such moulds the maintenance engineer will be well advised to give very frequent inspection and test to such parts as the ejector rods, rail alignments, guide pillars, etc., to ensure that the rail always returns to exactly the same point after each stroke. This will usually be best secured by arranging for a purely mechanical return mechanism rather than one dependent upon springs or manually operated levers.

Furthermore, cleanliness will play a large part in the continued efficient operation of this portion of mould mechanism, and to facilitate this the design and construction of the mould generally should conform to those which afford easy access for all essential cleaning, lubricating and adjusting operations, without

having to remove components, withdraw the mould from production, or to undertake extensive dismantling activities before such operations can be effectively carried out. Where difficulties confront the mould user in respect of cleaning, lubricating, etc., there will be added tendency to neglect such functions. Care will also have to be taken to maintain the ejector rail and rod secure in their fastenings, free from undue slackness, yet capable of easy movement at all points of their stroke. The guide hole for the ejector rod and insert pin will also have to be frequently checked for detection of signs of wear, especially at the point of its entry into mould cavity.

There is still another important point worthy of mention in respect of this mould construction shown at Fig. 1, because neglect of this may easily lead to serious mould damage. It will be noticed that the front portion of the insert pin, which normally has to project within the finished moulded article, is made to reside within a recess machined centrally up the forward end of the fixed core in the stationary block.

Unless the insert pin in all such constructions is correctly held and suitably fitted within the ejector rod guide hole, misalignment may occur in respect to the recess in fixed core. Thus, if the insert pin is too slack a fit in its housing in the movable block, or should it be slightly bent, its front end will tend to sag down off centre of the recess in fixed core. The writer has very often met examples of costly mould damage being wrought by this simple and overlooked snag.

To obviate such troubles some little care will be required; particularly will this apply in cases where the insert pins are of very slender proportions, and thus more liable to become bent, twisted and distorted during handling.

A mishap caused in the above manner may result in permanent damage being inflicted to the endface of the fixed core member; or it may be moved back out of its correct setting; the ejector rod may be forcibly trapped and jammed in its guide hole; or the insert pin may be so badly trapped between endface of fixed core and the ejector rod as to entail very great trouble in its removal; the edge of the guide hole in which the insert is held may be badly bruised and enlarged; or the cavity wall at this point may suffer severe damage, due to the trapping of the insert pin. All these and other troubles are likely to arise if there is a risk of an insert pin becoming trapped when the mould blocks are closed.

The alert and far-seeing maintenance toolmaker will constantly be on the lookout for evidence of developing trouble of this kind. The present writer has found it most helpful to undertake judicious instruction of the machine operator, in order to train him to use due care and observation when operating moulds carrying pre-formed inserts located in the manner being discussed. When closing the blocks, if any excessive tightness is observed, the cycle should be stopped and the blocks immediately opened again, in order to ascertain the reason for the observed additional resistance. Where there is co-operation and understanding between the mould maintenance toolmaker and machine operator, with the latter well trained to observe the evidence of minor operating snags of the kind mentioned, much can be accomplished to avoid the more serious troubles. Therefore the operator should be instructed on all these points by the toolmaker.

Strict insistence will also have to be maintained upon the tolerance or permissible errors in respect of the insert dimensions. An effective inspection system will have to be inaugurated where there is the slightest risk of an unsuitable insert being used. The writer is fully aware, however, of the difficulties and objections to such a plan, especially on the part of the small-scale moulder. Usually such metallic pre-formed inserts are purchased out or supplied by the user of the moulded article, and inspection generally is carried out at the place of origin rather than in the moulder's works.

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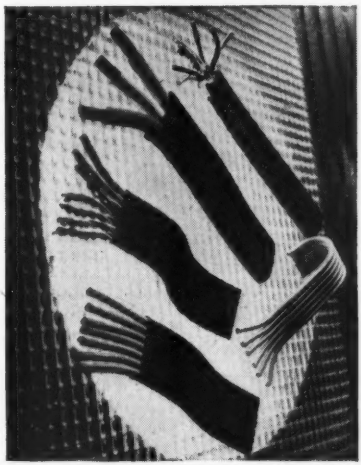

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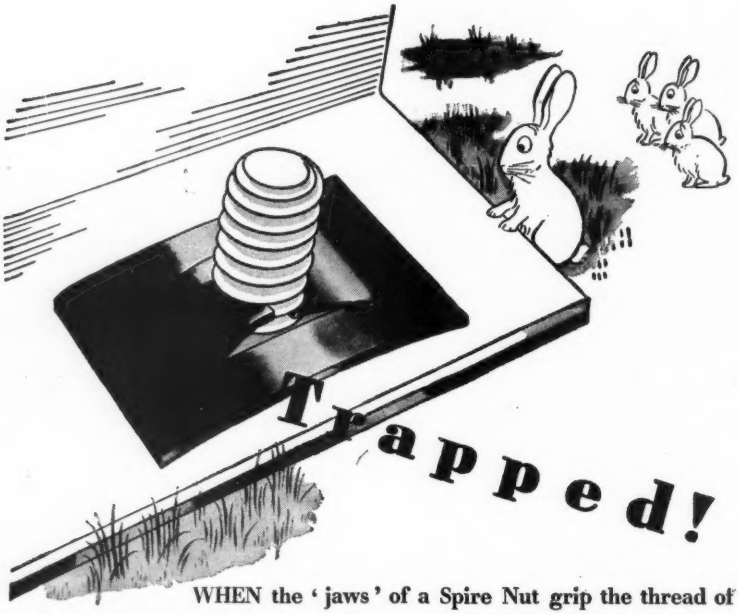

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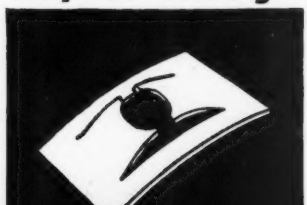

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which has been used by the present writer with excellent results, for permitting each insert component to be rapidly checked before admission to the mould. This method will appeal particularly to the more modestly equipped moulding shop lacking specialized personnel for exclusively conducting such important inspection duties.

It should also be borne in mind that inserts should be checked not only for adherence to dimensions, but also for freedom from burrs on those portions to be inserted into the blocks, presence of oil, chips, dirt, and so on, and for straightness in the case of rods or tube, or pins employed as inserts.

The method simply consists of fitting a hardened-steel sleeve into the ejector-rod guide hole, which latter may have

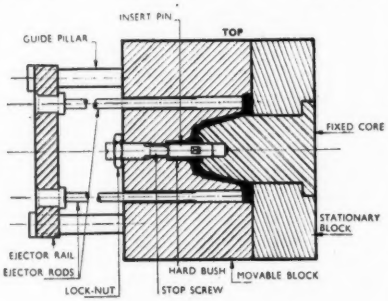

Fig. 2

to be enlarged for a short distance for this purpose. This sleeve should be a close sliding fit in the hole. The bore of the sleeve is such as will permit an insert pin to pass within singly but without slackness. A number of such sleeves may usefully be provided, as will be explained later.

In operation, the machine operator first takes one of these sleeves and places an insert stud within its bore, afterwards inserting both sleeve and assembled insert pin into the housing provided in cavity. It should be explained that, where possible, the insert should have a step so that endwise location within the hardened sleeve is readily obtained. If it is not possible for this to be done, the sleeve might be made the exact length that the insert has to pass into the block guide hole. The operator would then insert the pin until endfaces of both line up exactly.

When the finished moulding is ejected from the mould, done, incidentally, in the normal manner, the hardened sleeve will come away also and can then be easily withdrawn from projecting insert pin for use over again. If two or three such sleeves are provided as spares, the operator will be able to fit another insert into the sleeve whilst the moulding cycle of a previous assembly is being performed, thereby saving a little time.

This method ensures that each insert pin is tested for correctness of fit, cleanliness, and absence of bruises, etc., before placing it in the mould, so that any undesirable features will stand a far greater chance of being detected. The mere act on the part of the operator of placing each insert within a specially prepared sleeve ensures a more or less automatic check on its correctness. It may be said that this will occupy much time and therefore be uneconomical, but after only a little practice a surprising degree of deftness and speed will be developed by an operator. But the chief advantage of the plan is that it certainly enables production to be maintained at a consistently high level instead of being characterized by frequent stoppages for conducting clearance of the mould members and numerous minor adjustments or corrections.

A Simple Alternative Construction

In Fig. 2 is shown a much-preferred alternative mould construction for producing this cup-like component, which is largely free from all the foregoing operating risks and troubles, secured with little extra tool cost. One great advantage is that maintenance service will be kept at a minimum, as there is little that need go wrong with the simple mechanism.

In the improved design reliance for correctly locating and holding the insert pin is not secured by housing it within

the end portion of the ejector-rod hole as before. Instead, the bottom of the cavity area is machined with a parallel recess larger in diameter than the outside of the insert pin. It is brought down to this latter dimension by a hardened-steel liner driven tightly into the hole. The liner sleeve is easily replaceable at little cost should undue wear arise. The rear end of this hole is tapped out to receive the threaded stop screw, as shown. The front end of this screw is reduced in diameter down to bottom of threads, and the endface machined dead square and flat. One small lock-nut is situated on the left-hand overhanging end of this stop screw whereby the latter may be securely locked in any required longitudinal position relative to the mould block. This provision of an adjustable stop for the positioning of the insert will be found extremely convenient to the maintenance toolmaker having to make adjustments and variations in the lengthwise location of an insert.

Ejection of a finished moulding is accomplished by means of two small rods disposed each side of the central insert boss, and bearing against the flanged portion of the component, as illustrated.

It will also be observed that the guide pillars required for the control of the movement of the ejector rail are provided with enlarged heads at their extreme left-hand end, which serve as positive checks to the leftward travel of the ejector rail. These pillars, of course, should be very rigidly secured to the rear face of the movable block so that there is no possibility of their working loose due to operating vibration and jar.

The amount of clearance between the right-hand end of the insert pin and the bottom of the recess in the fixed core member in the stationary block is also much greater than in the previous construction, thereby obviating those troubles due to trapped air, collection of foreign substances, etc., and consequent mislocation of the insert.

Another extremely useful adaptation often utilized by the writer relates to the use of a stop screw of this type for securing the endwise retention of a steel (or similar magnetic material) insert part. It will often be found helpful to magnetize strongly the contacting front end of such a stop screw so that the force set up will tend to draw inwards, towards the screw, the inserted pin. This simple provision will often be found a useful safeguard against the accidental shifting out of proper place of an insert, which will usually be very smartly held in its correct position. No undesirable effects will arise when the finished part has to be ejected.

One of the advantages of reducing the contacting end portion of the stop screw is that it provides a shallow space beyond the point of contact into which accumulating dirt, oil, etc., may fall without causing interference with the positioning of the insert pin. If any dirt should lodge therein the action of pushing in a fresh insert pin will tend to sweep the accumulation forward into the recess provided. This minor point should be constantly watched in all cases of insert housing design, especially where screwed portions of the insert have to be inserted, as such machining tends to the accumulation of minute chips, shavings and cuttings on the portion concerned, these being easily deposited in the guide hole as the insert is moved into or out of position.

Mechanical Means to Prevent Endwise Movement of Insert

It is often highly desirable that some means be provided for the more positive retention of an insert in its housing hole so as to prevent departure from correct moulding location, and this subject has already received considerable attention in the previous section, which, however, largely dealt with provisions applicable to supporting pins and studs upon which tubular or hollow inserts had to be retained during the moulding cycle. Some of these apply also to the holding of the insert itself.

At Fig. 3 is illustrated yet another extremely simple but effective method which may often be adopted in circumstances where the insert stud, etc., is

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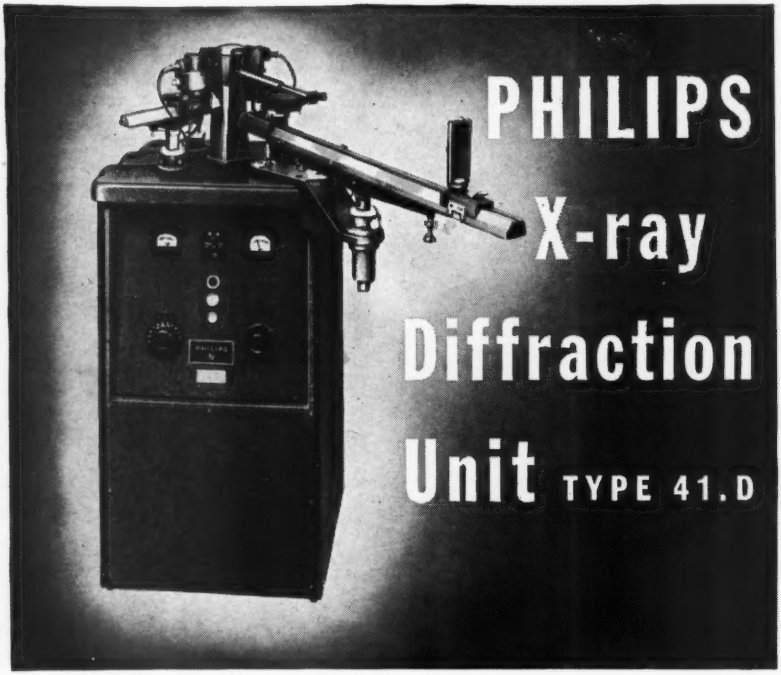

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horizontally disposed within the mould block. The construction does not embrace the use of springs of any kind, the holding pressure imposed on the component is always uniform, no difficulties are created when admiting or withdrawing an insert, it is very reliable, and incurs a minimum of maintenance attention, as there is so little that can go wrong.

The illustration shows only a sectioned cut of the movable block, from which it will be seen that almost the entire cavity

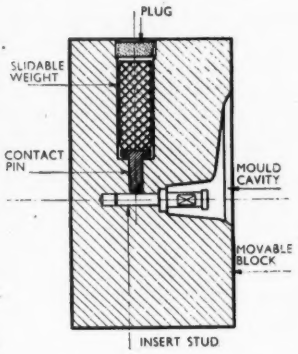

Fig. 3.

is machined therein. The component is a plastic handle having an extended boss at one end in which a plain, cylindrical pin has to be moulded-in, by which the handle can subsequently be fastened (by riveting) to a lever member.

This mould had to be worked at fairly high speed and it was soon discovered that troubles developed due to the tendency for the insert studs to move towards the right, out of proper position, as a result of the jarring action when the blocks were being brought to their closed position.

To overcome these troubles, it was decided to impart a steady retaining pressure upon the shank of the insert within the movable block. This was accomplished in the following manner. From the top face of the movable block was drilled a vertical hole passing clean into the longitudinal housing hole. About three-quarters of the full length of this hole was then enlarged to about three times the original diameter. Fitting very easily into this large-diametered portion of the hole was a lead or steel weight, cylindrical in shape, as shown. The lower end of the weight was caused to rest upon the enlarged head portion of the headed stud. This latter member was made a free-sliding fit within the small end of the hole. The purpose of the head is to prevent the stud from passing too deeply into the insert guide hole. A projection of its rounded end of about 3/32nds inch was allowed when the underside of its head was bearing on the step of the hole. The lower end of this stud was well rounded, almost semi-spherical in shape; in fact, in order that easy admission of an insert pin was obtained.

With this construction it will be noted that the weight slug being free to fall within its vertical hole will exert a steady pressure upon the headed pin and, via that member, to the insert pin itself, thereby tending to hold this latter in position. The whole arrangement is sealed off at the top of the hole against ingress of dirt, etc., by means of a very short screwed plug tightened down to the end of the short threaded portion at the mouth of the hole. When this plug piece is locked home the weight should be permitted a free movement of about $\frac{3}{16}$ in. The plug should, however, be made removable so that at very infrequent intervals the maintenance toolmaker may remove same in order to inspect the condition of the mechanism within.

This construction will be found extremely satisfactory and practically foolproof where lightweight insert members have to be dealt with, especially where these are located horizontally in the mould, as in the present instance. The arrangement will operate quite well at slight inclinations of the insert guide hole, but in such circumstances it will be found preferable to dispose the weight guide hole at right angles to the insert pin axis rather than square with sides of movable block.

Where additional frictional grip on the insert stud, etc., is required, this may

easily be obtained by substituting the headed steel pin between the weight and insert pin for one made in a material having a greater coefficient of friction. The writer has successfully used "Ferodo" or "Tufnol." On the other hand, the contacting endface of the steel pin might be lightly serrated to secure better grip.

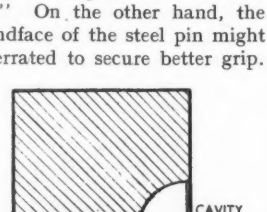

Fig. 4.

Delivering Inserts Into Inaccessible Mould Locations

Many difficulties often arise in connection with the necessity to locate and retain pre-formed machine inserts within deep, or narrow, or awkwardly shaped mould cavities. Especially will such troubles be aggravated if the feeding or positioning of the insert has to be manually performed instead of accomplished by automatic mechanical means. Circumstances such as these are often the cause for extreme retarding of the moulding cycle and costly diminished rate of production.

For these reasons, therefore, all such projected insert-locating constructions are well worthy of the closest consideration by the designer, mould engineer, and maintenance toolmaker in co-operation whilst the design is still in its elementary stages, in order that the most suitable form of insert and retaining or feeding means may be evolved to suit the peculiar circumstances of the cavity configuration.

At Fig. 4 is shown a partial sectioned view of the movable block only of a mould designed to produce a ball-type handle. This component is provided with a small-diametered long boss at one side, into which a screwed spindle or stud has to be moulded in place to enable the finished product to be attached to its mating unit. This is a good example of the difficulties likely to arise when the operator has to place an insert of small dimensions into the bottom of the mould cavity, as indicated. He will be unable to see into the cavity area at all, so admission of the insert pin will depend entirely upon "feel." For the same reason he will not be able to see whether the insert is correctly seated down on bottom of boss portion of cavity, or whether the seating in the latter is properly cleaned before admitting a fresh insert.

Thus much needless time will be wasted in the operator's efforts to ensure that the insert is correctly located, in readiness for an injection shot.

A considerably improved design of insert retention to meet such adverse con-

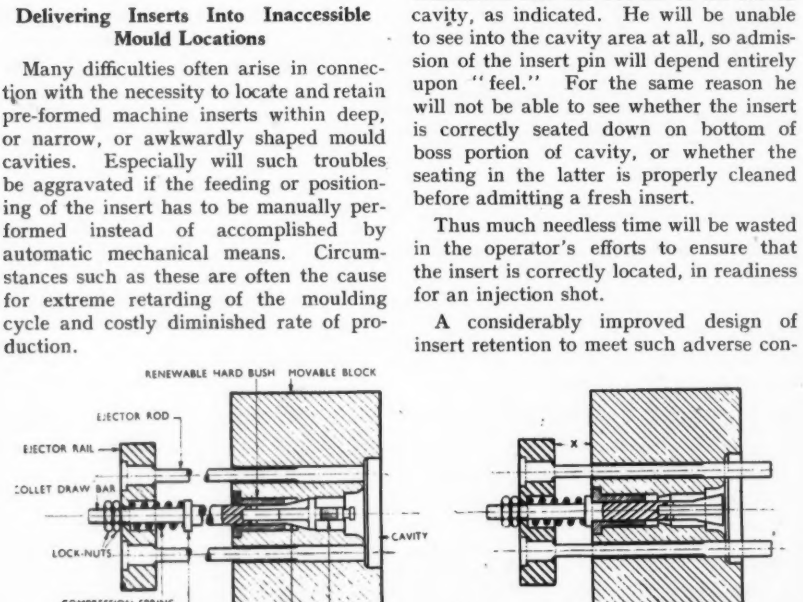

Fig. 5

ditions facing manual feeding is shown at Fig. 5, illustrated by two sectioned views, A and B, indicating the open and closed positions respectively. This design is presented for consideration because it possesses very wide versatility, being capable of numerous other similar applications. It is also a good example of a mechanism which will operate with trouble-free results, and it also has the added advantages of low installation cost and upkeep attention.

Referring first to the illustration A. Here the assembly of the movable block only is given. The plastic component to be produced by this mould is a flanged knob having a long cylindrical shank at one side, up the centre of which is moulded-in the steel shouldered stud needed to fix the knob in position on the handwheel for which it was required. In operating this mould before the construction was adapted in the improved manner about to be described, great difficulties were encountered when having to engage the insert stud into the deep cavity recess of the boss portion.

These troubles were obviated very effectively in the following manner:—

Attached to the ejector rail is a specially formed collet-ended drawbar. This consists of a plain cylindrical steel rod ground up on its exterior so as to be a close sliding fit within the bushed hole in the movable mould block. Its extreme left-hand end is threaded for a suitable distance to receive two steel hexagon lock-nuts. Some distance back from this threaded portion a shoulder is formed integrally with rest of rod, the function of which will be explained later.

The forward portion of this bar is made somewhat larger in diameter for a sufficient length to slide within the hardened-headed bush let tightly into the rear face of the block, as shown. The extreme front (right-hand) portion of the bar is enlarged in diameter for a short distance, this portion then being bored out dead central to a diameter in which the plain end of the stud insert shall fit closely. The outside of this short enlargement of the bar is then tapered as shown, and also afterwards slotted diametrically, so that the end is divided into four equal portions. A very narrow slitting saw should be used for this purpose, the aim being merely to divide up the end portion so that a certain degree of spring is imparted to same. The slots thus formed should extend well back, breaking into a pair of cross-located land holes provided for the purpose.

Thus in this way the right-hand end of the drawbar is made identical with an ordinary spring split collet, a tool extensively used for holding cylindrical workpieces for numerous machining processes.

This split end of the bar is then carefully hardened and tempered and finally ground up to exact size. As already mentioned, this bar slides in the hardened renewable bush or sleeve let into mould block, a member provided to facilitate adjustments for wear. The hole in which this sleeve is situated continues right through into the mould cavity in this case, and a short length of this hole adjacent to cavity wall is then made conical in shape to suit the tapered head of the drawbar, which latter part normally fits therein. A small step should be left on the cavity base wall between the largest diameter of the conical recess and that diameter of the cavity proper. This step serves as a positive check for the endwise location of the shouldered insert stud. The insert piece at every loading will be drawn to the left until its shoulder butts against this small step, this coinciding with the correct location of the insert.

The collet bar is attached to the ejector rail in the following manner, required because for a certain portion of the rail stroke the draw bar must move in unison with it, but is to be held stationary throughout the remaining portion. The threaded end of the collet bar is a free sliding fit, the clearance hole drilled through the ejector rail. This hole, it will be seen, is counterbored out a substantial depth on the inside face to admit the compression spring here shown. This spring is interposed between the bottom of the recess and the shoulder on draw bar previously mentioned. Two lock-

nuts capable of being tightly locked together on the collet bar on the left-hand side of the rail serve to prevent it being pushed too far to the right.

In the illustration at A the position of the collet draw bar, ejector rail, insert stud and connected mechanism are shown in the positions they occupy immediately prior to injection of a material charge. As will be seen, the ejector rail is drawn out of the movable block to its extreme position, the head guide pillars on which it slides and is checked for extent of movement, are not illustrated.

The collet draw bar is drawn back in a similar fashion until its conical head portion is brought into contact with the tapered recess on block. The bar should previously be adjusted by alteration and setting of the two lock-nuts so that the split collet end of the bar is closed inwards with sufficient pressure to grip the insert stud.

As will be understood in this position, the insert component will be very smartly and securely retained and will be unable to move from its correct position by any vibration set up from working the mould members.

Turning now to the related illustration B, also in Fig. 5, here we have the respective positions indicated of the various mould members immediately after ejection of the finished moulding has taken place and before the movable block has been sufficiently returned to move the collet bar to the left.

The ejector rail has been pushed forward to the right, carrying with it at the same speed the collet bar. The coil spring on bar will not be depressed, because there is very little pressure upon the collet bar as it is moving in time with the ejector rods pushing off the finished moulding. But when the collared portion of the collet bar contacts the endface of the movable block, as shown, further movement of the bar is arrested, and the ejector rail and rods will be free to continue the remainder of the ejection stroke by the amount shown at X, thereby not only pushing the finished moulding completely out of the cavity, but at the same time shedding the fixed insert stud from the slotted end of the cavity bar.

This is also the loading position for a fresh insert stud, and for this purpose the operator first arrests the return cycle of the mould block whilst he places a fresh insert component into the now exposed and easily accessible spring collet end of bar. In this position it will be an extremely simple and rapid movement performed with a minimum of interruption in the moulding cycle, and absence of all risk of mislocation.

The shank of the insert stud should be pushed well into the bore of the collet end of bar, this portion having sufficient spring due to tempering and splitting to hold the stud securely. Once the movable block is permitted to move forward again to the right the compression spring around the bar will cause it to move again in unison with the rail until this latter is arrested in readiness for the injecting stroke. The insert stud by this time will have been drawn down into mould cavity to its correct position.

This arrangement is capable of working very fast, is almost foolproof, and has a minimum of operating parts, so ensuring that little can go wrong or that its maintenance will involve much attention. Whilst the illustrations in Fig. 5 depict this type of insert retainer as applied to operate in an horizontal position, there are many other similar applications possible. For instance, with little adaptation the mechanism can be arranged to function with equal satisfaction in either a vertical or angular position. In such cases, of course, it may not be possible to secure its operation direct from the movement of the ejector rail as here shown. But the bar could very well be actuated by means of an angularly disposed pin attached to the stationary mould block and passing through a suitable hole in the bar, so that when the blocks are parted the bar will be duly withdrawn the requisite amount.

Or, again, such a bar could be attached to a slide let into the movable block and operated by means of a small rack and geared pinion, the rack being attached to

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the top edge of the stationary block and the pinion gearing with same but pivoted on a bracket fixed to the moving block.

Doubtless mould designers and engineers will readily envisage numerous simple and inexpensive applications which may be made of this type of insert retaining device to overcome some of the difficulties enumerated in the foregoing pages.

Inserts Located in the Parting-line Plane

Very often it is necessary to locate an insert component upon the parting-line surface of the mould block, so that it shall abut into the side of the mould cavity. It will be observed that all the previous examples have dealt with the task of locating and holding an insert which has to be projecting into the cored opening of the moulding, or else projecting from one end.

Very many illustrations could be given of the problems raised for both the mould designer and maintenance toolmaker by this need for location of an insert in the side wall of a moulded article, but only one can here be given because of lack of space.

Usually it is easily possible to arrange for the definite longitudinal positioning of the insert pin, etc., which has to be housed on the parting-line plane, but some positive means must be found to ensure its being effectively retained whilst the mould blocks are in motion.

This will be more fully appreciated by referring to the sketch at A in Fig. 6, which shows a partial diagrammatic and sectioned view of the movable mould block in which a saucer-like moulded article has to be formed having a moulded-in insert at one side, as shown. This cylindrical insert peg is housed in a semi-cylindrical hole cut into the parting-line surface of the mould block. In the stationary block a similar semi-cylindrical hole is cut to embrace the insert peg, but, unfortunately, this is only encompassed when the blocks reach their closed position. At all points previous there will be distinct danger of the insert falling out of place.

Such arrangements as this, one would have thought, are patently highly undesirable, yet the design is very frequently encountered. Usually various subterfuges have to be adopted by the enterprising operator to overcome the inability of the insert peg to stay put when moulds are open. These dodges comprise smearing the insert hole with thick grease or

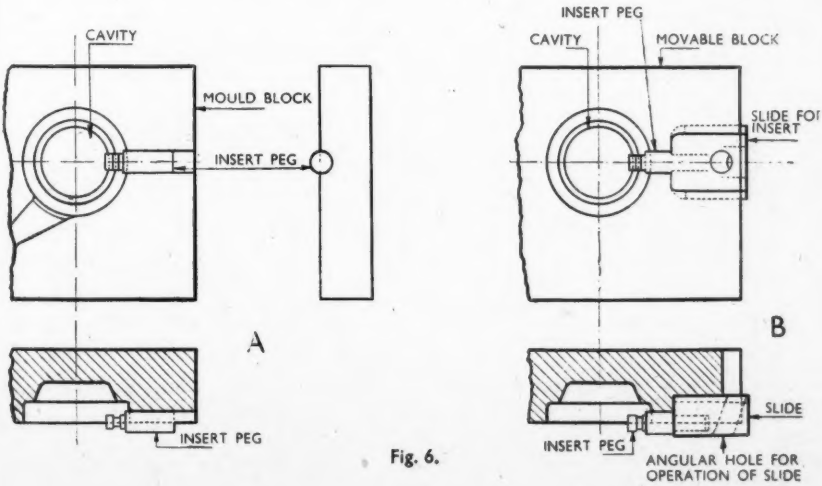


Fig. 6.

other sticky material whereby the insert can be stuck in place. Small bruises sometimes are deliberately formed on the sides of the half-hole, so that the insert has to be lightly tapped into place. All such artifices, however, whilst they may assist in maintaining production at a somewhat higher rate, do contain very great risk of serious mould damage being caused, and it should be remembered that only a single failure has to occur and very costly damage may accrue.

At B in Fig. 6 is indicated a most effective and far more preferable way in which the design should be arranged so as to eliminate altogether the worst features noted in respect to the mechanism at A.

Instead of seating the insert peg into a half-cylindrical hole, the mould block parting-line surface is machined out some way back from edge of cavity so as to take the rectangular slide. This latter member may be fitted either by means of dovetail guides or by suitable steps at each side, it being retained in position by small keep strips secured to block.

The front endface of this slide should be drilled so as to permit the insert peg to be passed easily into the hole. The slide is operated to and fro the required amount needed to carry the insert into the proper position within mould cavity, and also to clear the overhanging portion extending from the side of the finished moulding. This movement is imparted by means of an angularly disposed pin fixed to the parting-line face of the stationary mould block. This is clearly shown in the two views of the slide and block, etc., at B.

This construction enables an operator to place the fresh insert peg in correct position when the mould blocks are in open position, thus affording full access, and then to close the blocks in the full confidence that it will be brought into its proper position for moulding and be retained there safely. Furthermore, once the moulding has been completed and ejection takes place, no fouling of the insert carrying slide can take place, since its movement is constantly timed with that of other important mould members.

This latter point, by the way, is one sometimes overlooked by both designers and engineers, and often too great a reliance has to be made upon the degree of observation and intelligence of an operator to ensure that each moulding cycle is completed without inflicting damage to the mould, due to the possibility of trapping the insert carrying or locating mechanism with other moving parts of the mould with which they are not interlocked or appropriately timed.

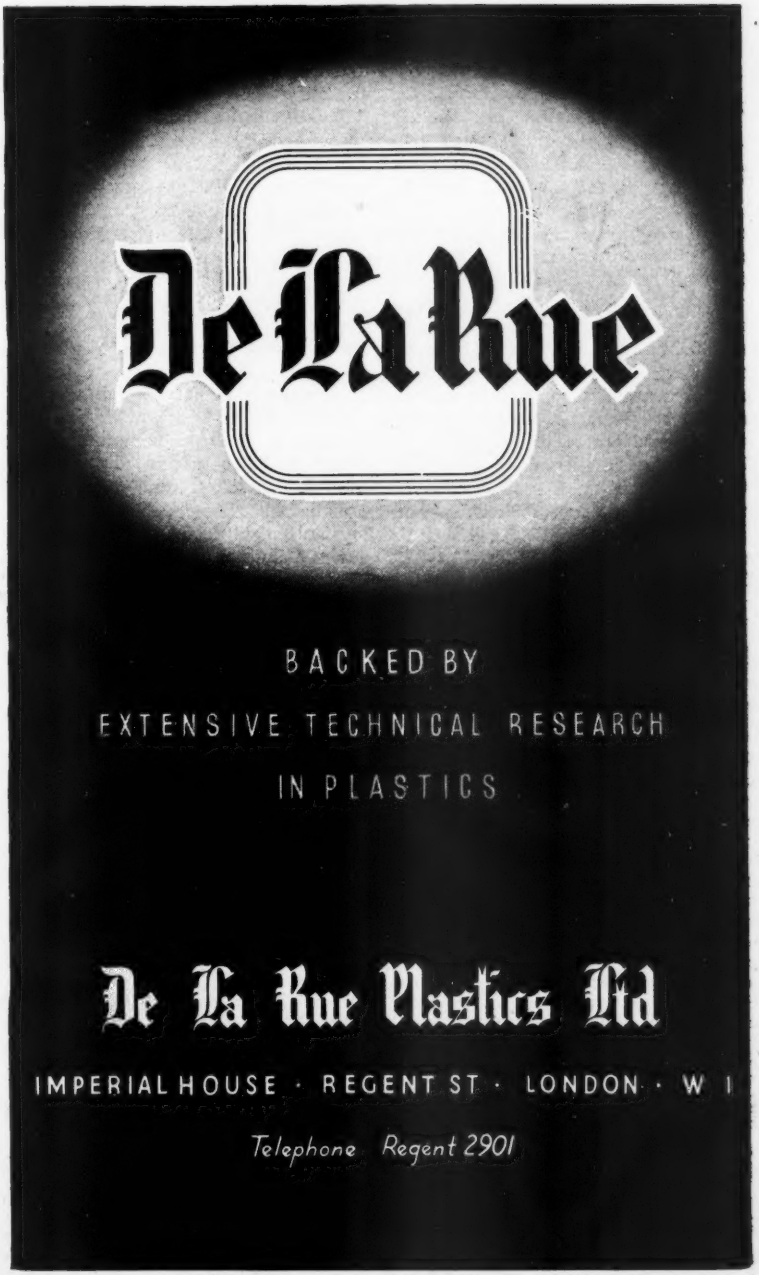
For inserts of cylindrical shape and of small overall dimensions, such as the one here illustrated, this is a very suitable form of retention, as it guarantees that the part cannot fall out whilst moulds are being operated. But it should also be pointed out that one slide, if made sufficiently large, may serve to house and deliver a number of insert pins of the kind shown. On the other hand, there is no reason why several such insert carrying slides should be incorporated in a single mould construction as the design demands.

The Multiple-insert Mould Construction

When a mould construction requires a large number of insert components, it should always be borne in mind that the moulding cycle is liable to be still further prolonged, and one effect of such extension in moulding time is apt to be overlooked. This is the danger of losing the correct mould-working temperature as a result of the additional time needed for placing all the inserts into position. For this reason it may be advisable for the designer to sectionalize the feed of the inserts, and to introduce preloading plates, or even automatically operated magazine feeders.

Another important point, again somewhat neglected, concerns the use of inserts of very large surface areas. Such parts are apt to absorb a large amount of heat, and it may easily be found that introduction of a number of such inserts will drastically lower the working temperature of a mould, thus leading to other operating troubles.

Still another difficulty often occurring,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due to use of inserts, relates to porosity in the finished moulded part. Sometimes complicated shapes of inserts are employed, in which air may be trapped, or small quantities of cutting oil lodging from the machining operations may give rise to undesirable gases when contacted with the hot plastic material. This is likely to arise also in connection with moulds having numerous inserts.

In the next section, therefore, the author will endeavour to deal with the above and some associated problems. Hand-operated magazine feeding, semi-automatic and fully automatic methods of insert feeding will be discussed, and certain undesirable and preferable designs forms will be remarked, it is hoped, for the better guidance of the designer and maintenance toolmaker, both of whom are so vitally concerned in overcoming or avoiding the various difficulties and operating snags described throughout this present article.

In conformity with the main line of approach followed throughout this entire series of articles, the author will submit a number of representative types of mechanism covering each particular problem in order to illustrate clearly the best and most unsatisfactory features contained.

It should be stressed here that the writer will endeavour to choose the simplest forms of construction of all such moulds, rather than to select complicated forms. The reasons for such a choice will be twofold. First, other things being equal, far less maintenance oversight, attention and inspection is required from the simpler forms of mechanism in which there are few working members than in the case of highly complex constructions. And, secondly, because the writer knows from experience that given due study and display of a little originality it is easily possible to design simple forms of constructions, such as preloading magazines capable of being rapidly and reliably installed in between "shots" by hand, or semi-automatic feeding devices capable of giving prolonged trouble-free service without risk of inflicting serious injury to other mould members, or entailing too stringent demands upon the memory, intelligence and temper of the operator.

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We have received the following notes from a correspondent in India, following a visit to the laboratories of the Council of Industrial Research, which is part of the organization of Delhi University. Considerable research work is being done on plastics:—

In the main the work has been centred upon the use of indigenous materials, and some interesting work has been done with shellac. Yet another field which has been explored is the production of protein fibres from ground nut, and a moulding powder which appears to be phenolic in character is obtained by modifying the oil from "washing nut" (the local name) with scrap rubber.

Protein fibres.—These are made from ordinary ground nuts, and the first stage is the removal of the husks. This is followed by a crushing process to remove the oil. The remaining meal is pressed into a cake and subsequently treated chemically to reduce it to the form of a viscous solution. This is extruded through a spinnerette in the normal way and finally hardened. Good tensile figures are claimed and these drop by about 60 per cent. when fibres are wet.

Shellac.—A great deal of work is being done with shellac, and a wide variety of samples of laminates were seen. In particular, fabric (jute) and paper were used as the base. Tensile figures up to 15,000 lb./sq. in. are claimed. These laminates have been produced in several forms, such as in corrugated sheets suitable for roofing, and attempts were made to make a bullet-proof sheet about an inch thick by embedding expanded metal, or $\frac{5}{16}$-in. steel balls in jute fibres impregnated with shellac and surfaced with normal jute woven fabric. The results were not successful.

A method of deep-drawing fabric laminates (shellac) has been perfected, although details could not be given, as the patents are not yet finalized. The results, however, are astonishing, and articles having a depth/diameter ratio in excess of 1 : 1 have been made.

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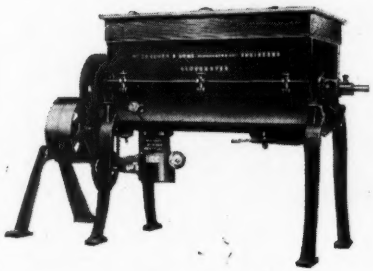

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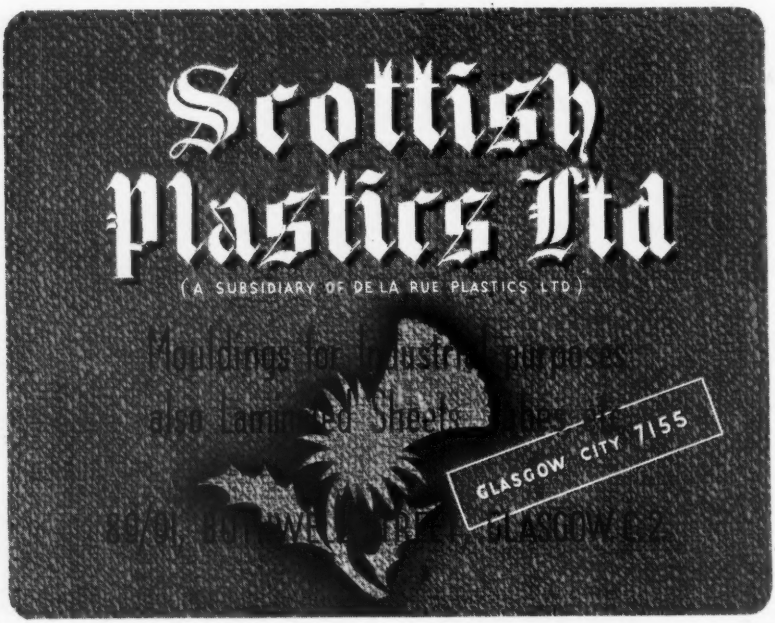

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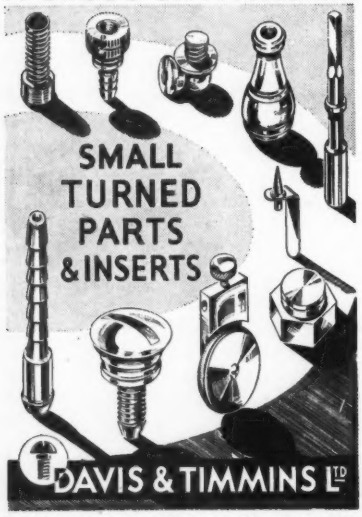

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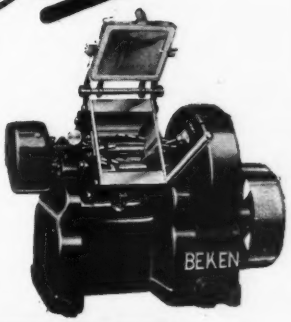

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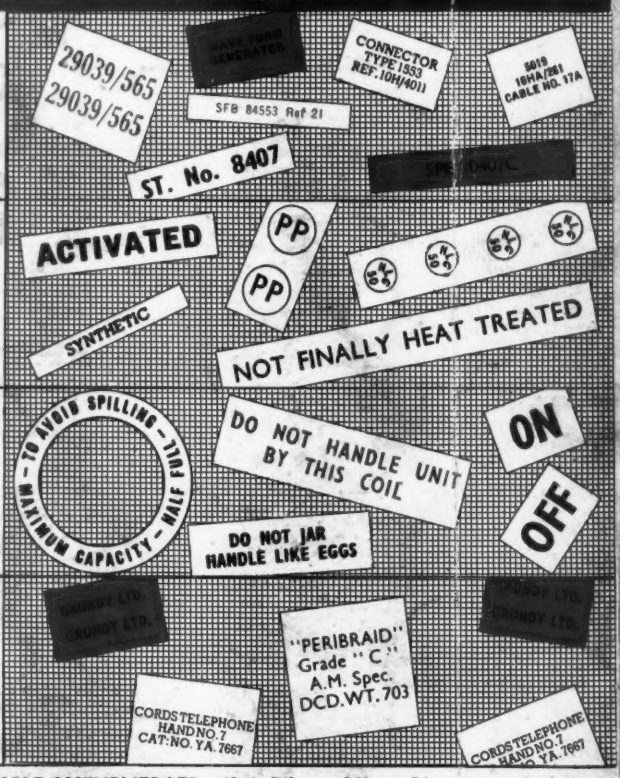

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